5664.900 Savina

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Navigation tips

Words in blue are hyperlinks (except for the Dräger logo). Clicking on these hyperlinks will open the document at the corresponding text or view.

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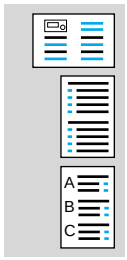

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Opens the table of contents.

Opens the keyword index.

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Dräger

Periodic Manufacturer's Service (PMS)

File no.: 5664.900
Edition 08.2001

DrägerService

Savina

Installation site: _____

Explanation of Symbols

—	OK	Z	= Check condition
|	Defect/error/fault	F	= Check function
◯	Spare parts used	D	= Check for leaks
/	Report	P	= Enter value
∩	Accessories missing		

Serial no.: _____

Date of delivery/ startup: _____

Invoice no. or delivery no.: _____

Other: _____

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SW 01.n
SW 02.n

1. Device in general

Composition of the inspection price:
Basic unit with one expiratory valve. Additional expiratory valves must be charged separately.

1.1 Software version

Enter software version of Savina.

P

1.2 Options as per rating plate

BIPAP/PCV+ P

Autoflow P

Central alarm P

NIV (mask ventilation, SW 02.n or later) P

1.3 Operating hours

The operating hours can be read out under "Config" in the Savina menu.

1.3.1 Total hours of operation

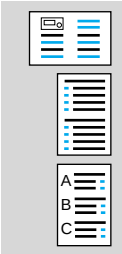
Enter total operating hours.

P

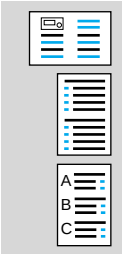
1.3.2 Service operating hours

Operating hours since last service.

P



1.4	General condition	Z	
1.4.1	Accompanying documents		
	Instructions for use and medical product logbook available according to operators.	Z	
1.4.2	Device rear panel		
1.4.2.1	Dust filter set		
	Replace dust filter, if necessary. Dust filter must not be pressed together.	Z	
1.4.2.2	Ambient air filter		
	Replace ambient-air filter, if necessary.	Z	
1.4.3	Power pack		
1.4.3.1	DC connection for external battery.		
	Connection has no visible damage.	Z	
1.4.3.2	Cooling air fan		
	Switch on the unit. Check condition and functioning of cooling air fan. Switch off the unit.	Z F	
1.4.4	O_2 inlet block.		
	Inlet block is fitted with NIST, DIN or DISS connectors.		
	Check condition and tightness of inlet block.	Z D	
1.4.5	Inspiration block		
	Check condition of inspiration block.	Z	
1.4.5.1	Inspiratory socket		
	Check condition of inspiratory socket.	Z	
1.4.6	Nebulizer connection		
	The nebulizer connection is marked with a nebulizer symbol.	Z	
1.4.7	Flow sensor mount (flow sensor)		
	The flow sensor can be inserted into its mount and moved to the right and to the left without effort.	Z F	
1.4.7.1	Flow sensor		
	The flow sensor is undamaged.	Z	



1.4.8 Expiratory valve mount

Check locking function. Z F

1.4.9 Expiratory valve(s)

Enter serial number of valves:

Valve 1: P

Valve 2: P

Valve 3: P

1.4.9.1 Expiratory valve, complete

See also test item 2.1.

Inspect the following components. To do so, remove the respective expiratory valve:

Diaphragm, complete
Non-return valve
Flow sensor sleeve, complete
Lip seal (for pressure measurement)
Expiratory socket
Water trap container

Valve 1: Z

Valve 2: Z

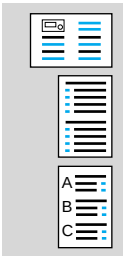
Valve 3: Z

Assemble each expiratory valve ready for use.

1.4.10 Savina front panel

1.4.10.1 Keypad, control knob, and display

Keypad, control knob, and display are undamaged (for example, have no scratches that could affect the view). Z



1.4.11 "Savina Mobil" trolley

1.4.11.1 Castors

Wheels, of which 2 locking. Check screw fittings for secure seating to 25 Nm. Z F

1.4.11.2 Trolley accessories

Check condition and function of the following accessories (if fitted):

Humidifier holder (optional)

Cylinder holder (optional)

"Multiple socket outlet" retrofit kit (option)

Battery pack (option, in trolley pedestal)

External battery connecting cable Z F

1.4.12 Unit accessories

Check condition and function of the following accessories (if fitted):

Hinged arm (if fitted) Z F

Temperature sensor (if fitted) Z

1.4.13 Compressed gas connecting tubes

Compressed gas connecting hoses comply with national regulations.

For example, compressed gas connecting hoses with sealing rings, neutral color
for O_2 NIST connectors, 3 m,
for O_2 NIST connectors, 5 m, Z D

1.4.14 Hose systems

Hose systems correspond to specifications in the Instructions for Use/Operating Instructions. Z

1.4.15 Adult test lung

Check condition and completeness of adult test lung.

The adult test lung comprises the following components:
Face mask angle piece
Catheter connector, ISO, size 7
Breathing bag, 2 L Z

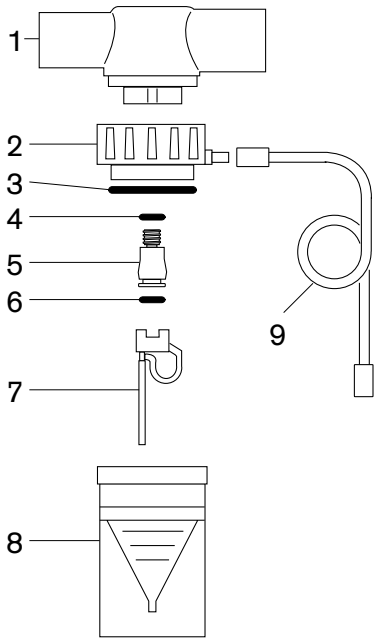
The breathing bag must not be overstretched.

1.4.16 Drug nebulizer (white housing)

Additional note:
The drug nebulizer, 84 05 000, (black housing), must not be used in Savina.

1.4.16.1 Condition test

Check the condition of the following components:



1 Patient connection
2 Nebulizer housing
3 Gasket
4 O ring
5 Nozzle
6 O ring
7 Atomizer
8 Container
9 Nebulizer hose

Z

1.4.16.2 Functional test

Fill nebulizer housing with water up to the "3" mark. Supply drug nebulizer with 2.0 bar ± 0.2 bar.
Test: Vapor must be produced.

F

1.4.17 Special accessories (if provided)

Check condition and function of the following special accessories (if available):

Resutator 2000

Child Resutator 2000

Z F

1.5 Unit options and configuration

– Not applicable –

2. Replacement of wear and tear parts

2.1 * Replace diaphragm, complete, 84 13 661, in the expiratory valve.

Next replacement:_____

2.2 * Replace internal batteries (rechargeable), 18 41 416, (x2) every 2 years
(see also chapter "Maintenance Procedure Replacing the internal rechargeable batteries").

Next replacement:_____

2.3 * Replace batteries (rechargeable), 18 43 303, (if fitted, x2) in Savina Mobile every 2 years.

Next replacement:_____

2.4 * Replace O2 filter, 84 08 208, and sealing ring, M 09 257, in valve block, complete, every 6 years.
(see also chapter "Maintenance Procedure Replacing filter and sealing ring in O2 compressed gas inlet").

Next replacement:_____

2.5 * Replace O2 pressure reducer, 84 13 666, in valve block, complete, every 6 years.
(see also chapter "Maintenance Procedure O2 pressure reducer").

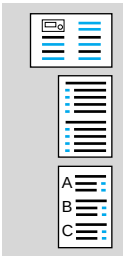
Next replacement:_____

2.6 * Replace real-time clock, 18 45 527, on Control PCB, every 6 years.
(see also chapter "Maintenance Procedure Replacing the real-time clock on the Control PCB").

Next replacement:_____

Note: After changing the real-time clock re-enter the date and time.

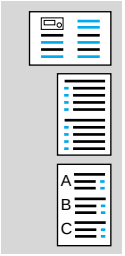
2.7 * Replace the blower unit with the "motor blower unit" spares set, 84 13 643, after 20000 hours' operation.
(see also chapter "Maintenance Procedure Replacing the blower unit").

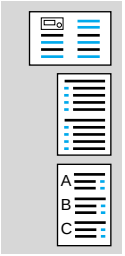


3. Electrical safety test

See document " Electrical Safety Test in the USA/Canada".

Record measured values in the document "Electrical Safety Test Form Savina".


A
B
C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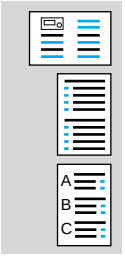
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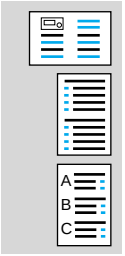
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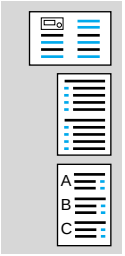
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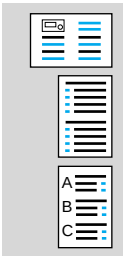


4. Functional tests

4.1 Power pack

Connect mains power and O2 supply. Switch on the unit.

4.1.1 Testing the "electrical supply" display

The LEDs on the front of Savina show the following operating states:
Mains power supply: green
External battery: off
Internal battery:
Green: Internal rechargeable batteries are fully charged.
Yellow: Internal rechargeable batteries are being charged. F

4.1.2 Testing the internal supply voltage

Cut mains power.

The unit continues to ventilate. Audible alarm sounds and display message "!! Int. battery activated" appears. F

The LEDs on the front of Savina show the following operating states:
Mains power supply: off
External battery: off
Internal battery: green F

4.1.3 Testing the supply voltage failure alarm

Connect device to the mains power supply.

Remove the fuse for the internal rechargeable battery. The fuse is located on the rear panel of the unit.

Disconnect the device from the mains power supply.

Ventilation off. All LEDs are off. Audible alarm sounds. F

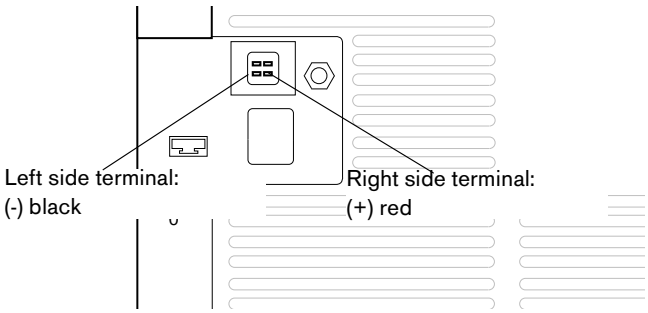
Switch off the unit.
Restore mains power.
Re-insert fuse for internal rechargeable battery.
Switch unit back on.

4.1.4 Testing the external d.c. voltage supply

4.1.4.1 Battery operation simulation

Notice: Maximum test duration = 1 minute!

“Connect Charge tester (Evita), complete" to d.c. voltage input of Savina (use the two lower sockets).



Using "DC voltage source, 3 -18 V" apply a voltage of 14 V to the charge tester.

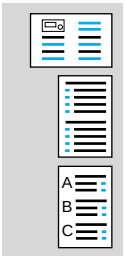
After 6 seconds, at the latest, the LEDs on the front of Savina show the following operating states:
Mains power supply: green
External battery: green
Internal battery:
Green: Internal rechargeable batteries are fully charged.
Yellow: Internal rechargeable batteries are being charged.

F

Reduce the voltage from the DC source from 14 V to 11 V.

The LEDs on the front of Savina show the following operating states:
Mains power supply: green
External battery: yellow
Internal battery:
Green: Internal rechargeable batteries are fully charged.
Yellow: Internal rechargeable batteries are being charged.

F



4.1.5 On-board electrical system simulation

Short-circuit the two upper sockets on the d.c. voltage input of Savina using the "Cable for charge tester".

Set the voltage from the d.c. source to 14 V and wait for the "External battery" LED to light up green.

Reduce the voltage from the DC source to 11 V.

The LEDs on the front of Savina show the following operating states:
Mains power supply: green
External battery: green
Internal battery:
Green: Internal rechargeable batteries are fully charged.
Yellow: Internal rechargeable batteries are being charged.

F

Remove the charge tester. Switch off the unit.

4.2 Tests in internal service mode

Switch on Savina and, at the same time, press and hold the backlighting dim-up/dim-down key and the "Config" key until the service mode is activated (see also chapter "Service Mode Entering the Internal Service Mode").

4.2.1 Checking the RS232 interface

Test Step 0 : call up this test step.

Connect PC to Savina using "RS232 extension" and "RS232 adapter, crossed". Start terminal program and adjust the following:

COM 1 (or corresponding)
Baud rate: 19200
Data bits: 8
Parity: None
Stop bits: 1
Protocol: None

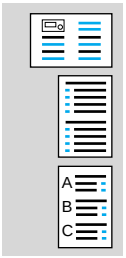
The settings on the PC must match those in the Medibus log of the Savina in the "Configure" menu.

Carry out "Send Logbook" function in internal service mode.

Test value:

The content of the error log is displayed on the PC (terminal program).

F



4.2.2 Testing the keys

Call up test steps 1 and 2 in sequence (as of SW 1.10)

Check the functioning of all keys.

Test value:

All keys should function properly.	F	

4.2.3 Nebulizer flow test

Test Step 13: call up this test step.

Connect a flowmeter tube with an oxygen scale of up to 16 L/min to the nebulizer connection. Switch on the nebulizer valve.

Test value:

Nebulizer flow = 8 L/min to 14 L/min.	P	

4.2.4 Comparing measurement functions of the flow sensors

Test Step 14: call up this test step.

Connect (short-circuit) the inspiratory and the expiratory sockets using a ventilation hose. Set the "PRESSURE BYPASS" value to 40 mbar.

Test value:

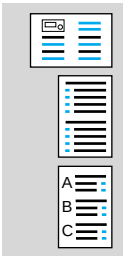
The measured inspiratory and expiratory flows must not differ by more than 13%.	P	

4.2.5 Offset voltages of the airway pressure sensors

Call up test **19**.

Test values:

"V_PAW_INSP" = 730 mV ±100 mV	P	
"V_PAW_EXP" = 730 mV±100 mV	P	



4.2.6 Testing LEDs, 7-segment displays, and LC display

Call up test step 25

Set "Test target" value to "LED".

Test value:

All LEDs should be evenly lit. F

Set "Test target" value to "LCD".

Test value:

The display shows no pixel errors. F

Set "Test target" value to "7-segment".

Test value:

All 7-segment displays are lit evenly. F

4.2.7 Plausibility test

Compare O2 supply pressure sensor with ambient pressure sensors.

Test Step 27: call up this test step.

Cut the O2 supply and relieve the pressure.

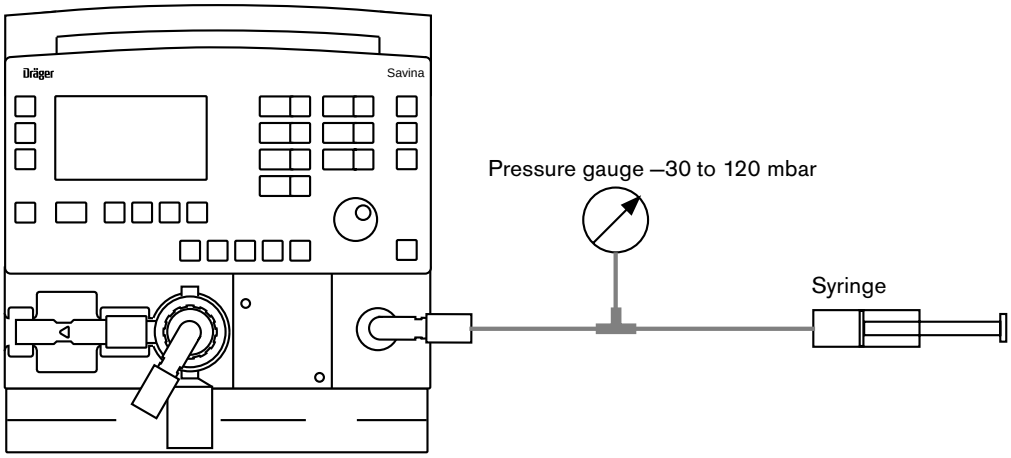
Test value:

The three displayed values must not differ by more than 7%. P

Switch off the unit. Cut the connection to the PC.

4.3 Leak test, inspiration

Test set-up:



Using the syringe build up a pressure of 40 mbar ±1 mbar at the inspiratory port.

Test value:

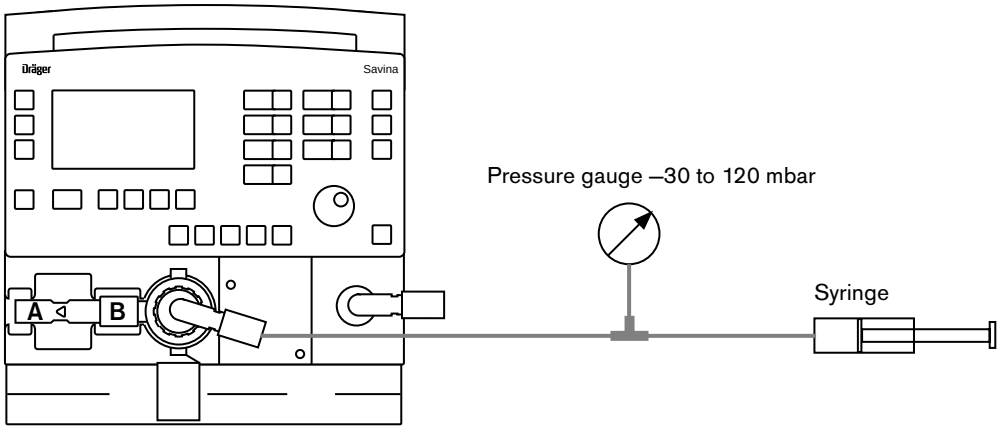
The volume injected via the syringe in 15 seconds must be < 25 mL.

D

4.4 Leak test, expiration

Remove the flow sensor (Spirolog sensor (**A**)) and sleeve (**B**). Seal the outlet of the expiratory valve and use the syringe to build up a pressure of 40 mbar ±2 mbar.

Test set-up:

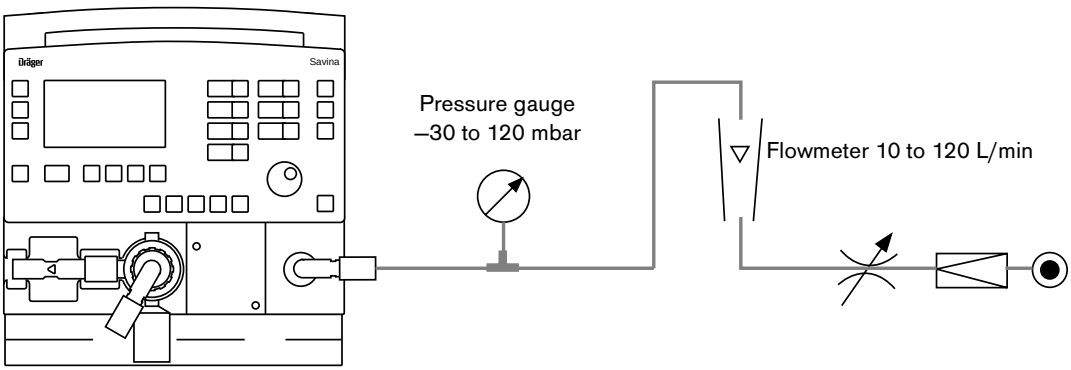


Test value:

The volume injected via the syringe in 15 seconds must be < 25 mL. D

4.5 Testing of "120 mbar valve D1"

Test set-up:



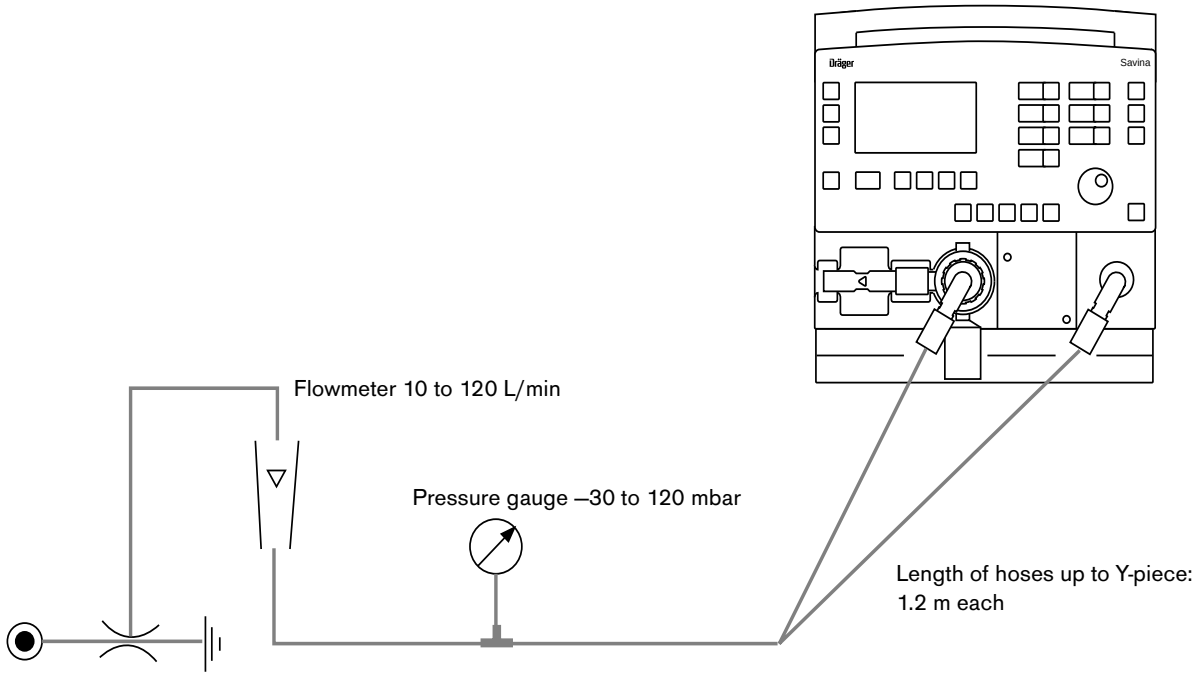
Increase the pressure until a flow rate of 120 L/min ±5 L/min is achieved.

Test value:

The pressure at the inspiratory port must be >100 mbar and <120 mbar. P

4.6 Testing "Emergency respiratory valve D2 (emergency air valve)"

Test set-up:



Switch off the unit. Through the test pressure regulator with injector set a flow of 60 L/min ±3 L/min.

Test value:
The pressure at the Y-piece must be between –3 mbar and –6 mbar. P

4.7 O2 supply pressure monitoring

Switch on the unit.
Disconnect the O2 supply.
Set the O2 concentration to 50%.

Audible alarm sounds and display message "!!! No O2" appears. F

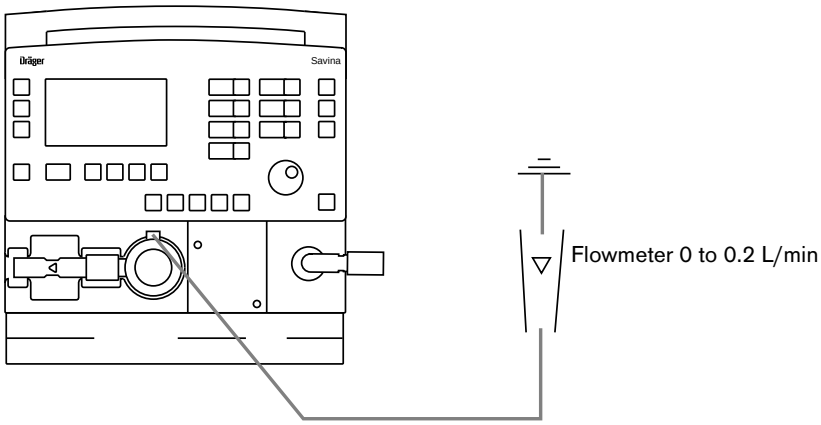
Restore the O2 supply.

4.8 Flush flow "expiration pressure measurement R1"

The O2 concentration of the flush flow corresponds to the set O2 concentration (select respective flowmeter tube).

Switch on the unit. Remove the expiratory valve.

Test set-up:



Test value:

The flush flow must be in the range > 0.02 L/min and < 0.2 L/min. P

4.9 Testing valves V8/V9 (emergency venting) and tightness of "Emergency respiratory valve D2"

Connect unit to test lung and adjust the following parameters:
Operating mode = IPPV, AutoFlow OFF,
Pmax OFF,
Vt = 0.5 L,
Tinsp = 5 s,
f = 6 1/min,
O2 = 21%,
PEEP= 5 mbar,
Paw high = 10 mbar above peak pressure

Seal Spirolog sensor.

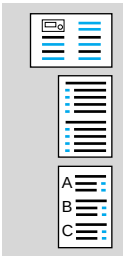
Test value (pressure curve shown on display):

Pressure build-up to "Paw-high limit", then drop to < 6 mbar. F

4.10 Testing the "Backlighting" key

Press the "Backlighting" key.

The backlighting comes on or goes off. F



4.11 Testing the contrast

Change the contrast in the "Config" menu.

The contrast of the display changes. F

4.12 Testing the micro-filter detection

Remove the micro-filter The micro-filter is located on the rear panel of Savina behind the filter cover.

Audible alarm sounds and display message "!!! No ambient air filter" appears. F

Fit micro-filter and cover.

4.13 Testing the Spirolog sensor detection

Remove the Spirolog sensor (flow sensor).

Audible alarm sounds and display message "!!! Flow Sensor?" appears. F

Re-insert the Spirolog sensor.

4.14 Testing the temperature measurement

4.14.1 Test using AWT sensor dummy

Connect the AWT sensor dummy and switch to "Test" and 34 °C.

Read out temperature value from "Values" menu of Savina.

Test value: Display = 34 °C ±1 °C F

Remove the AWT sensor dummy.

4.14.2 Testing of temperature sensor (if fitted)

Connect the temperature sensor and take a reference measurement at room temperature.

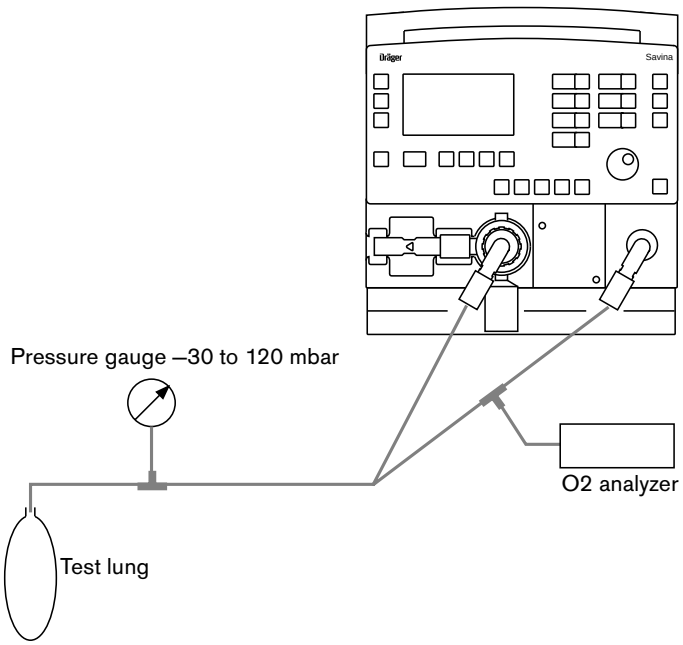
Test value:
Permissible deviation between display on Savina and Thermometer: 2 °C F

4.15 Testing the ventilation

4.15.1 Testing ventilation and O2 mixing in IPPV mode

Set the following values:
Operating mode = IPPV, AutoFlow OFF,
Pmax OFF,
Vt = variable,
Tinsp.= 5 s,
f = 6 1/min,
O2 = 40 vol%,
PEEP = 5 mbar,
Paw alarm limit = max

Test set-up:



Test value:

Test O2 concentration using a separate O2 analyzer, e.g. Oxydig. The value indicated by Savina must be 40 vol.% ±1 vol.%. Read out Vte from "Values" menu of Savina.

In order to increase the O2 concentration faster, set the frequency to f = 12 1/min and Tinsp = 2 s. As soon as the O2 concentration is reached, reset values as specified previously.

Table 1: IPPV measured values

Set inspiratory Vt in mL	Measured expiratory Vt* in mL	O2 concentration in vol.% (Oxidig)
100	96 ±15	40 ±2
200	192 ±26	40 ±2
1000	960 ±130	40 ±2

*The measured expiratory Vt refers to the patient's lung conditions (BTPS).

P

4.15.2 Testing of pressure-controlled ventilation

Units with BIPAP option: continue with test step 4.15.2.1. All other units: continue with test step 4.15.2.2.

4.15.2.1 Testing the pressure controlled ventilation in BIPAP mode

Set the following values:
BIPAP,
f = 6 1/min,
Paw = max,
PEEP = variable,
Pinsp = variable,
P_{ASB} = 0 mbar,
O2 = 80 vol.%,
Tinsp.= 5 s,
FlowAcc = 60 mbar/s

Test set-up:

As in test step 4.15.1.

Test value:

Test O2 concentration using a separate O2 analyzer, e.g. Oxydig. The value indicated by Savina must be 80 vol.% ±1 vol.%.

In order to increase the O2 concentration faster, set the frequency to f = 12 1/min and Tinsp = 2 s. As soon as the O2 concentration is reached, reset values as specified previously.

Table 2: BIPAP measured values

PEEP setpoint in mbar	Set Pinsp in mbar	Actual PEEP in mbar	Actual Pinsp in mbar	O2 concentration in vol.% (Oxidig)
5	25	5 ±2	25 ±2	80 ±3
20	60	20 ±2	60 ±2	80 ±3
5	25	5 ±2	25 ±2	80 ±3

P

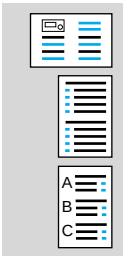
Continue with test step 4.15.3.

4.15.2.2 Testing the pressure controlled ventilation in CPAP mode

Set the following values:
CPAP,
Apnea ventilation ON,
f_{Apnea} = 10 1/min,
Vt_{Apnea} = 2000 mL,
Paw = variable,
PEEP = variable,
O2 = 80 vol.%,
FlowAcc = 60 mbar/s

Test set-up:

As in test step 4.15.1.



Test value:

Test O2 concentration using a separate O2 analyzer, e.g. Oxydig. The value indicated by Savina must be 80 vol.% ±1 vol.%.

Table 3: CPAP measured values

PEEP setpoint in mbar	Pmax setpoint in mbar	Actual PEEP in mbar	Actual Pmax in mbar	O2 concentration in vol.% (Oxidig)
5	30	5 ±2	25 ±2	80 ±3
20	55	20 ±2	50 ±2	80 ±3
5	30	5 ±2	25 ±2	80 ±3

P

4.15.3 Testing trigger characteristics in CPAP/ASB mode

Set the following values:
CPAP/ASB,
Paw alarm limit high = 30 mbar,
PEEP = 5 mbar,
O2 = 40 vol%,
ASB = 20 mbar,
Trigger = 3 L/min

Test set-up:

As in test step 4.15.1.

Test value:

Unit does not trigger an ASB breath. F

Simulate breathing.

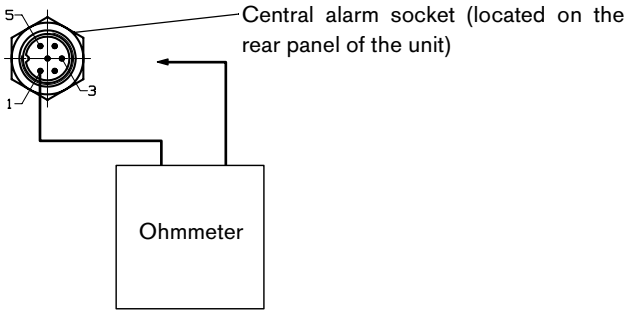
Test value:

Trigger LED must light up and ASB breath must be triggered. ASB pressure 25 mbar ±3 mbar. P

4.16 Testing the optional central alarm (if available)

Activate alarm, e.g. by pulling power plug.

Test set-up:



Test value:

Contacts "3" and "5" close if an alarm occurs.
Contacts "1" and "3" open. F

4.17 Service hours counter and log entries

Switch off Savina.

Switch on Savina and, at the same time, press and hold the backlighting dim-up/dim-down key and the "Config" key until the service mode is activated (see also chapter "Service Mode Entering the Internal Service Mode").

Call up test **0**:

Perform "DELETE LOGBOOK" function.

Call up test **3**:

Perform "RESET SERVICE HOURS" function.

5. Place fully functional unit at user's/owner's disposal.

---

6. Confirmation of test

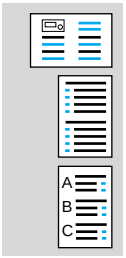
Name:

Date:

Signature:

* These steps are regarded as repair work and are therefore not included in the inspection service price.

7. Report:

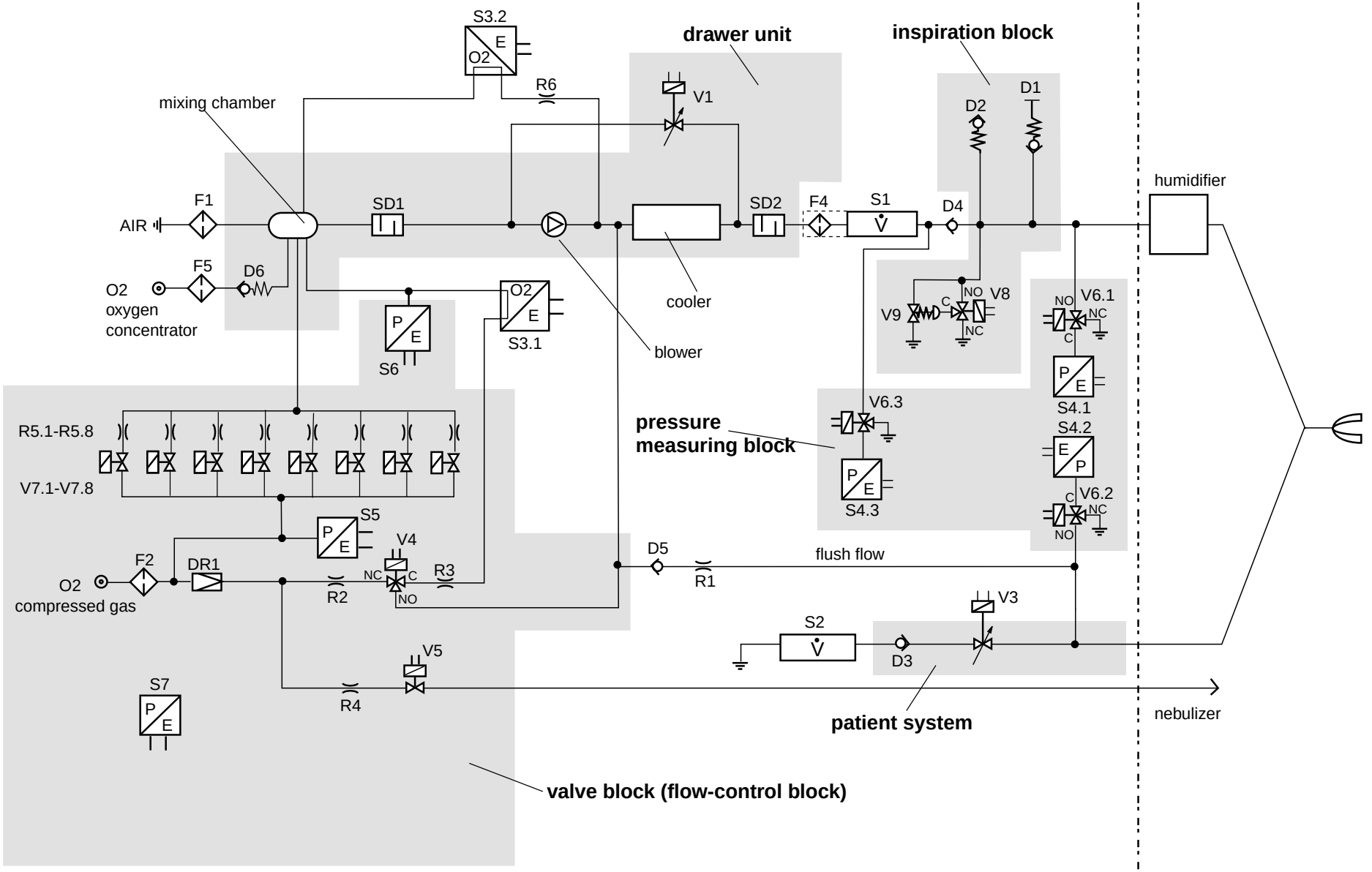


8. Annex

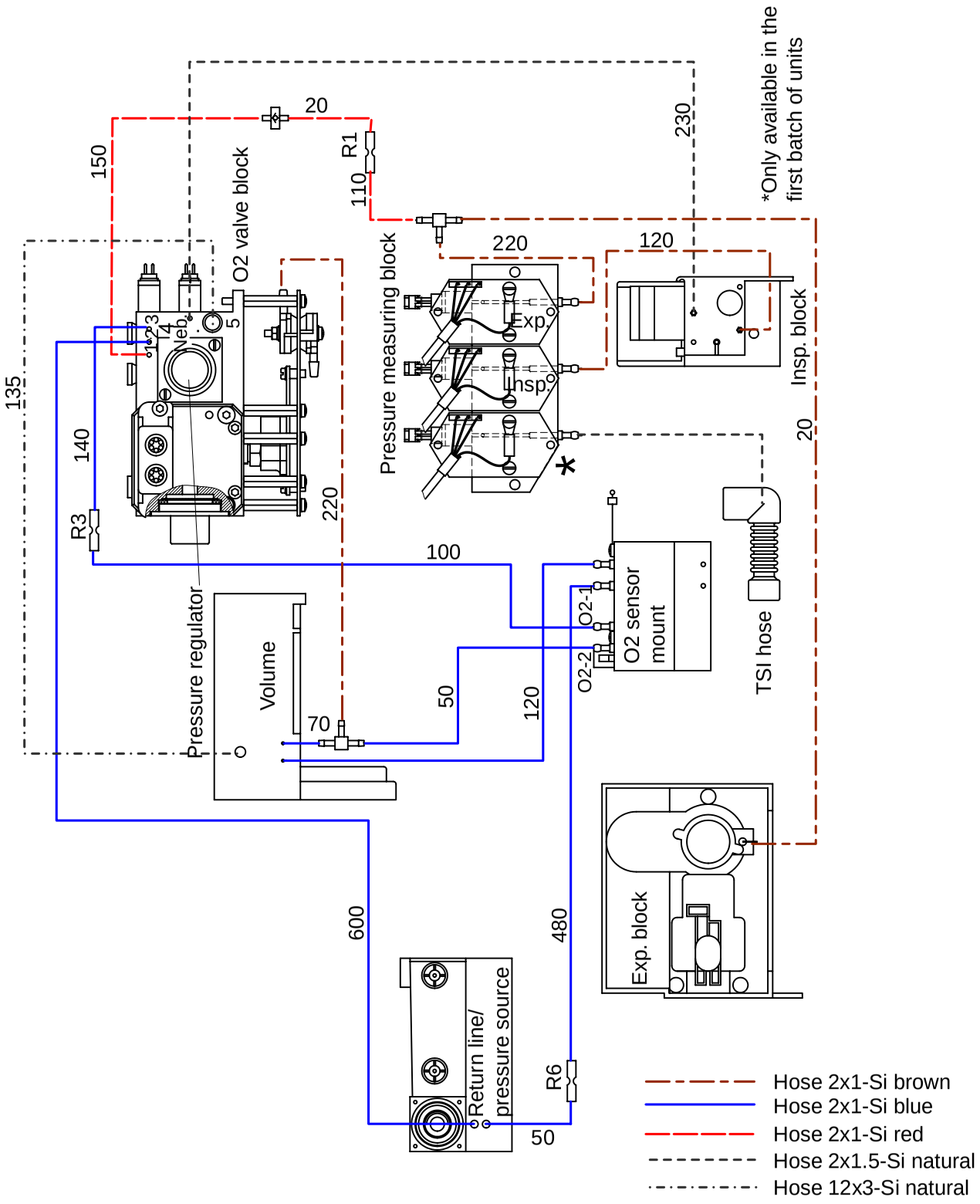
8.1 List of service equipment for Test Certificate

Table 4: Test Equipment

Designation	Order number
Test lung	84 03 201
Patient adapter for Paw measurement	8290285
Oxydig	8304411
Pressure gauge, digital 100 mbar	79 10 722
VDE tester	79 10 594
RS232 adapter, crossed	79 01 888
RS232 extension	79 01 808
Test pressure regulator	79 011 482
Injector	2M 06 912
Syringe, 50 mL	79 01 541
Flowmeter block	79 01 161
Flowmeter, 10 -120 L/min	79 00 718
AWT sensor dummy	79 00 405
Charge tester (Evita), complete	79 10 385
Cable for charge tester	79 10 387
Multimeter	79 01 021
DC voltage source, 3 -18 V	79 10 426
Thermometer	2M 11 111
For testing castors on trolley:	
Torque spanner	79 00 909
Special open-ended wrench, 17 mm	79 01 204
Special open-ended wrench, 41 mm	79 10 462


S3.2
O2
E
drawer unit
inspiration block
R6
V1
D2
D1
mixing chamber
humidifier
F1
SD1
SD2
F4
S1
D4
AIR
F5
D6
O2
oxygen
concentrator
O2
E
S3.1
cooler
V9
V8
NO
C
NC
V6.1
P
E
S6
blower
S4.1
R5.1-R5.8
V6.3
pressure
measuring block
S4.2
V7.1-V7.8
S4.3
V6.2
S5
V4
D5
flush flow
F2
DR1
R1
O2
compressed gas
R2
R3
V3
S2
D3
V5
S7
R4
patient system
nebulizer
valve block (flow-control block)

8.3 Tubing diagram



Service Strategy

Items to be repaired/Repair locations

What	Test instructions/test aids	Repair
Inspection	Test Certificate, service documentation	Minor repairs, battery replacement etc.
On-site repair	Test Certificate, service documentation	Minor repairs, e.g. changing a fuse, exchanging a module, calibration
Workshop repair	Test Certificate, service documentation	Minor repairs, e.g. changing a fuse, exchanging a module, calibration
Repair in Lübeck	Test Certificate, service documentation, design documentation	Repair at component level

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General notes

Electrostatic discharge may damage the electronic components. When handling electrostatic sensitive devices use static-dissipative mat and a wrist strap.

The O_2 sensors and batteries are special waste items. Dispose of the O_2 sensors and batteries in accordance with local waste disposal regulations.

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Maintenance Procedure

The maintenance procedure described here corresponds to the maintenance procedure set out in the Test Certificate. For the maintenance intervals refer to the Test Certificate: "Replacement of wear and tear parts". The following maintenance procedure is described:

– Replacing filter and sealing ring in O2 compressed gas inlet

– Replacing the O2 pressure reducer

– Replacing the blower unit

– Replacing the internal rechargeable batteries

– Replacing the real-time clock on the Control PCB

O_2 sensors, microbial filter, diaphragm in expiratory valve and dust filter see "Instructions for Use/Operating Instructions".

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Replacing filter and sealing ring in O_2 compressed gas inlet

- Switch off the unit.
- Disconnect the O_2 compressed gas supply.
- Open the unit (see "Removing the rear panel").
- Remove the micro-filter **1**.
- Remove the drawer unit **2**.

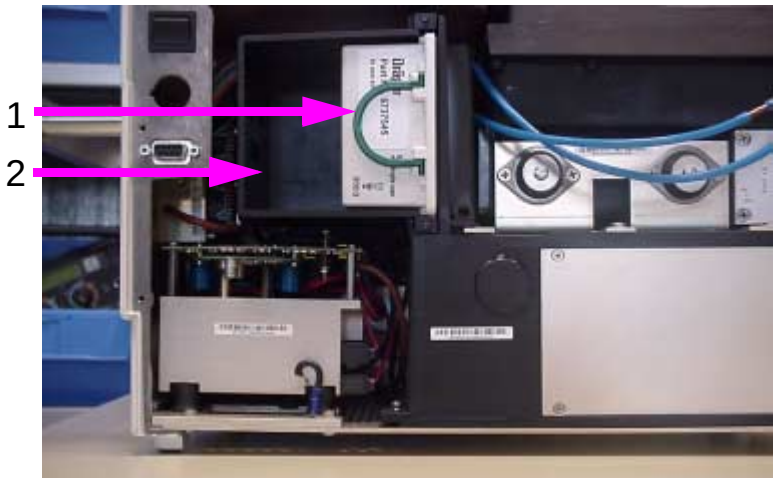

Fig.1: Removing the micro-filter.

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- Remove the screws **3**.

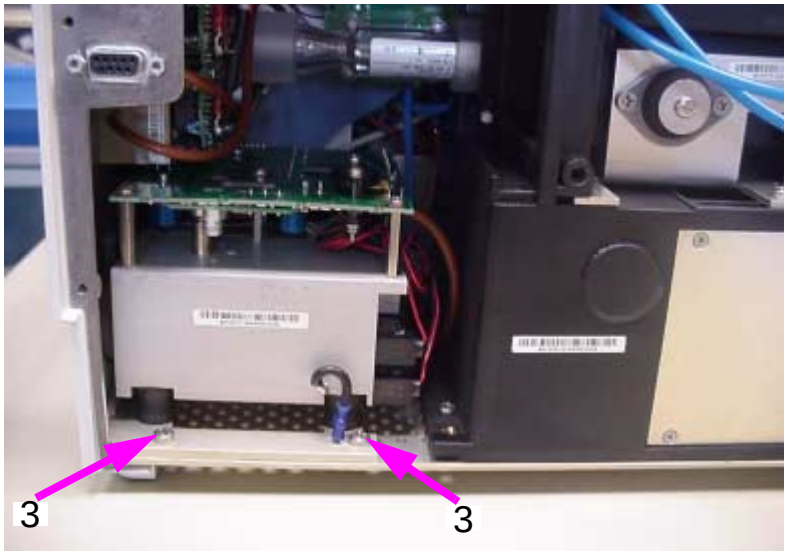

Fig.2: Removal of valve block 1

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Remove also the sealing ring from the NIST connector. Otherwise the sealing ring could be lost during further disassembly.

- Remove NIST connector (if fitted) and sealing ring.

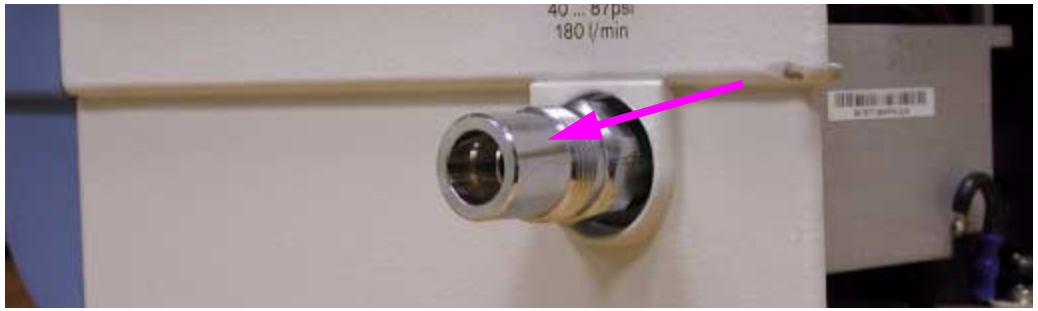

Fig.3: NIST connector

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- Remove inspiratory flow sensor from plug-in unit and push up.

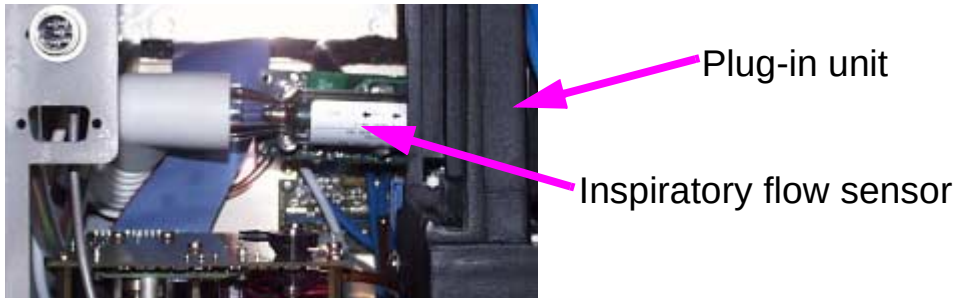

Fig.4: Removing the inspiratory flow sensor

- Remove large, transparent hose (which connects valve block to plug-in unit) from the plug-in unit.

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- Pull out the valve block a little and turn 90° counter-clockwise.

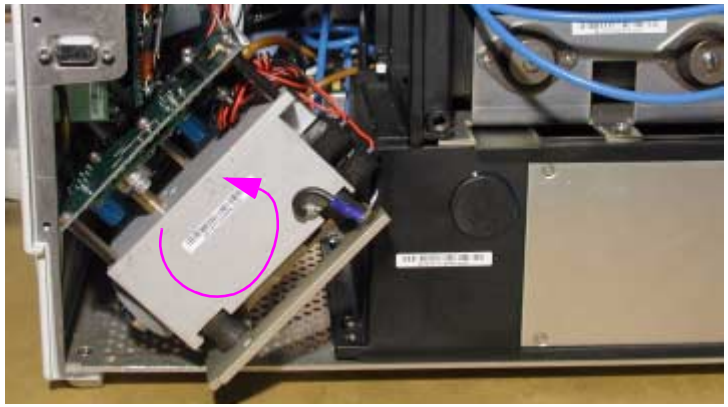

Fig.5: Turning the valve block

- Mark the hoses leading to the valve block.

Before removing the hoses from the valve block, mark them and make a note of their fitting positions.

- Remove the hoses.

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- Remove the connector of the O_2 Valve PCB.

Fig.6: Removal of valve block 2

- Remove the valve block.

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- Remove the screws **4**.

Fig.7: Removing the filter

- Remove the socket.

Before removing the filter and sealing ring, make a note of the fitting position.

- Remove the filter and sealing ring.

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- Insert the new filter and sealing ring.

If the O_2 pressure reducer needs to be replaced as well, proceed with "Replacing the O2 pressure reducer".

- Assemble the unit.

Make sure not to kink any hoses during assembly.

- Perform the safety check and functional check as per the Test Certificate.

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O_2 pressure reducer

Replacing the O_2 pressure reducer

- Remove the valve block (see "Replacing filter and sealing ring in O2 compressed gas inlet"). Follow the instructions given there from "Switch off the unit." to "Remove the valve block.").

Before removing the O_2 pressure reducer from the valve block, make a note of its fitting position and, after removing it, the connector layout (see underside of pressure reducer).

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- Remove the screws **1**.

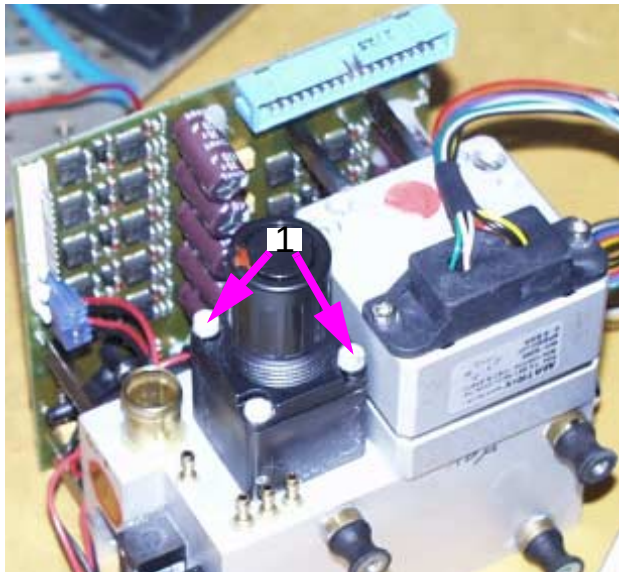

Fig.8: Replacing the O_2 pressure reducer

- Make a note of the fitting position.
- Remove the O_2 pressure reducer.
- Make a note of the connector layout.
- Fit the new O_2 pressure reducer and O-rings.
- Continue with "Adjusting the O2 pressure reducer".

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Adjusting the O_2 pressure reducer

To adjust the pressure reducer the valve block must be removed (see "Replacing filter and sealing ring in O2 compressed gas inlet". Follow the instructions given there from "Switch off the unit." to "Remove the valve block.").

- Connect the O_2 Valve PCB to the Savina.
- Connect the O_2 pressure supply.
- Connect pressure gauge, 0 to 6 bar (Use valid test equipment. The illustration shows only a schematic) to the nebulizer outlet of the valve block.

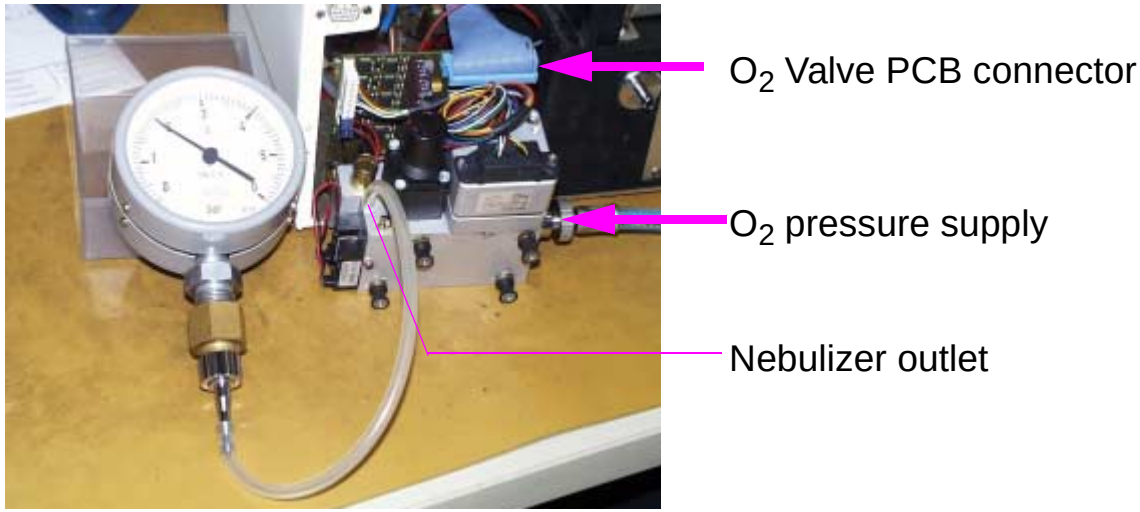

Fig.9: Pressure reducer test set-up

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- Switch on Savina and start service mode (see service mode, chapter "Entering the Internal Service Mode").
- Select Test Step 13.
- Switch on the nebulizer valve.

To adjust the pressure reducer the control knob must be raised. After making the adjustment the control knob must be pushed down again and secured with stop varnish.

- Raise the pressure reducer control knob.
- Adjust the pressure on the pressure gauge with the pressure reducer to 2 bar ±0.2 mbar.
- Push the pressure reducer control knob back down.
- Secure the control knob with stop varnish.
- Switch off Savina.
- Assemble the unit.
- Perform the safety check and functional check as per the Test Certificate.

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Replacing the blower unit

- Open the unit fully (see "Opening the unit").
- Remove the connector for the return valve (X644) from the Control PCB (see "View, Control PCB").
- Fold away the backing plate on which the Control PCB is mounted (see "Folding away the Control PCB").
- Remove the connector **1** from the Motor Commutator PCB.

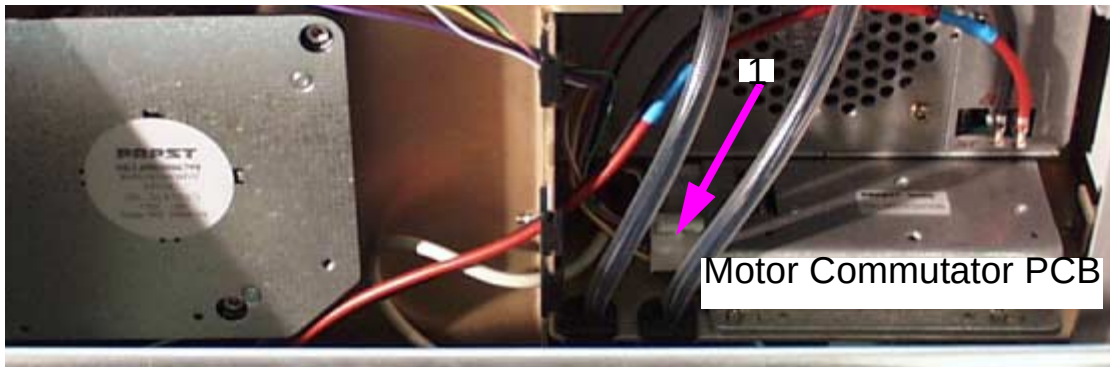

Fig.10: Motor Commutator PCB connector

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- Remove the screws **2** from the fan.

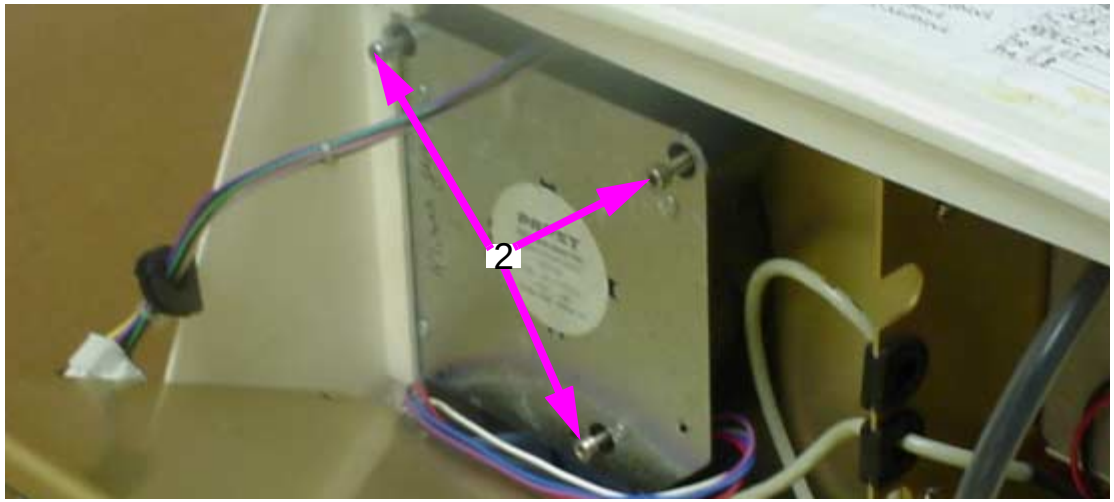

Fig.11: Removing the fan.

- Place the fan on the plate of the Control PCB.

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- Remove the micro-filter **3**.
- Remove the drawer unit **4**.

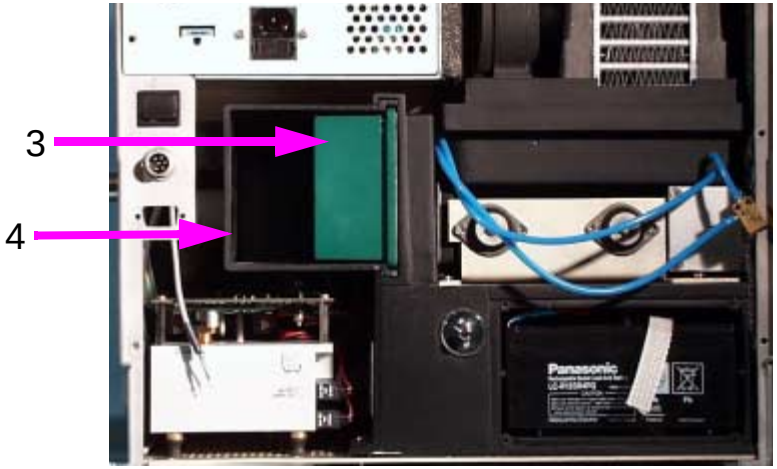

Fig.12: Removing the micro-filter.

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- Remove inspiratory flow sensor from plug-in unit.

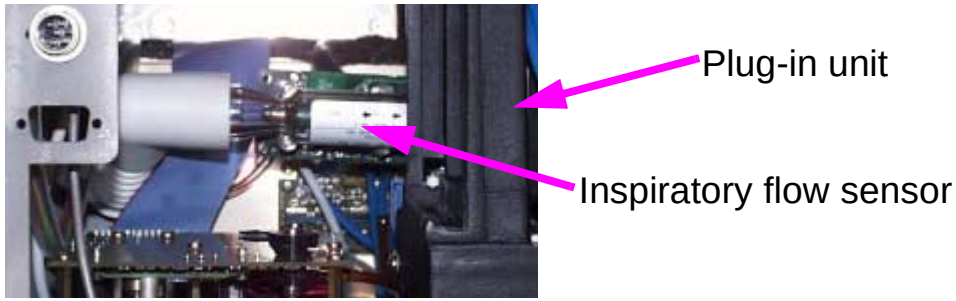

Fig.13: Removing the inspiratory flow sensor

- Remove the fixing screws **5** of the blower bracket.

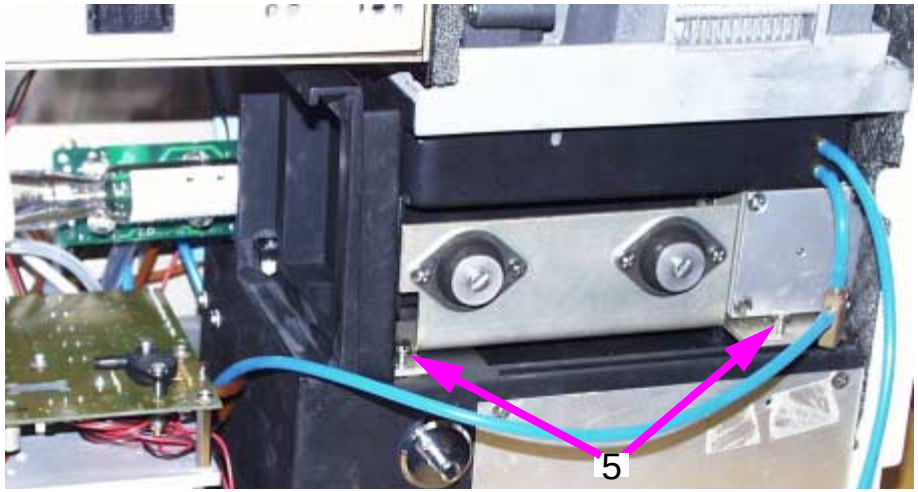

Fig.14: Slacken the blower bracket.

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When withdrawing the blower pay attention to the cable connections. The cable connections must also be fed out. The removed cables are those of the Control PCB and the Motor Commutator PCB.

- Push the side panel away slightly and carefully withdraw the blower out of the unit towards the rear.
- Remove the fixing screws **6** (screws are tighten to 1.2 Nm ±0.3 Nm).

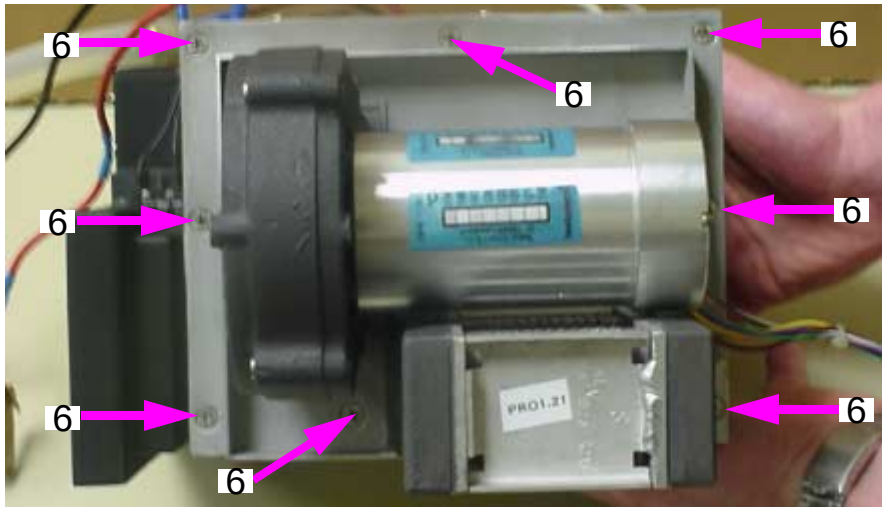

Fig.15: Removing the blower unit.

- Remove the blower block.

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- Remove the fixing screws **7**.

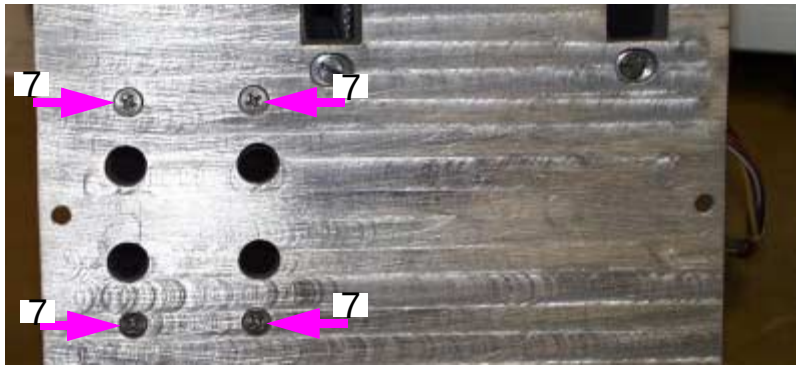

Fig.16: Removing the blower.

- Remove the blower.
- Install the new blower and seals.

The screws in step "Remove the fixing screws 6 (screws are tighten to 1.2 Nm ±0.3 Nm)." are tightened with to a specific torque.

- Assemble the unit.
- Perform the safety check and functional check as per the Test Certificate.

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Replacing the internal rechargeable batteries

- Open the unit (see "Removing the rear panel").
- Remove the fuse for the rechargeable batteries by levering it out carefully with a screwdriver.

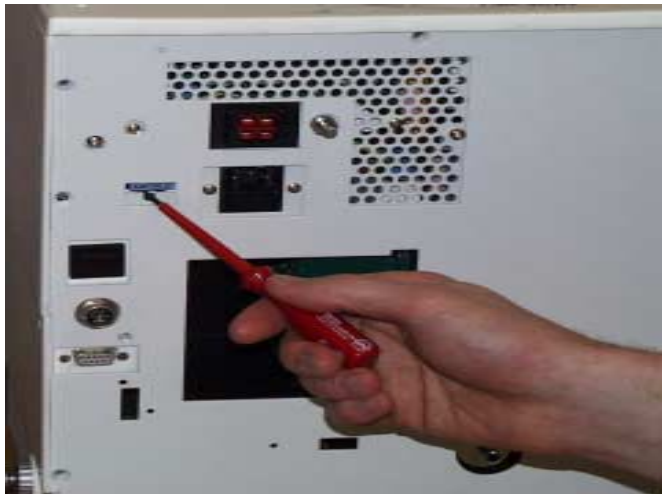

Fig.17: Removing the fuse of the rechargeable batteries.

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- Remove the screws **1** and the cover **2**.

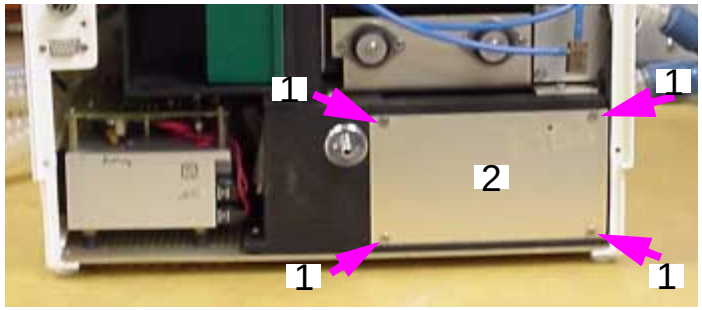

Fig.18: Removing the rechargeable batteries, part 1

The rechargeable batteries are special waste items. Dispose of the rechargeable batteries in accordance with local waste disposal regulations.

Reversing the polarity of the rechargeable batteries will damage the batteries and the power pack. Make a note of the connector layout and ensure correct polarity when fitting the rechargeable batteries.

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- Remove the rechargeable batteries.

Fig.19: Removing the rechargeable batteries, part 2

- Fit new rechargeable batteries.

Inadequate voltage. The new rechargeable batteries are not sufficiently charged. Connect the Savina for at least 10 hours to the mains supply (Savina does not need to be switched on).

- Assemble the unit.
- Perform the safety check and functional check as per the Test Certificate.

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Replacing the real-time clock on the Control PCB

Read the following information before replacing the real-time clock (RTC):

Do not replace the EEPROM and the RTC on the Control PCB at the same time. Otherwise the recorded operating hours will be lost. If you need to replace both components, do it in sequence, that is, complete the replacement of one component first before starting the next one.

Replace the RTC only with a brand-new RTC that has not been in use before.

The unit must be off when replacing the RTC.

Ensure the correct polarity. If the polarity of the RTC is reversed the RTC will be destroyed. Remember the installation position of the RTC.

The RTC has a battery. Dispose of the old RTC according to local waste disposal regulations.

The RTC keeps information about operating hours and settings, e.g. alarms and configurations. This information must be read out and written down before replacing the RTC.

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- Read out and write down operating hours and settings, e.g. alarms and configurations.
- Switch off the unit.
- Open the unit (see "Opening the operator control panel").
- Remove the RTC (D19) from the Control PCB.

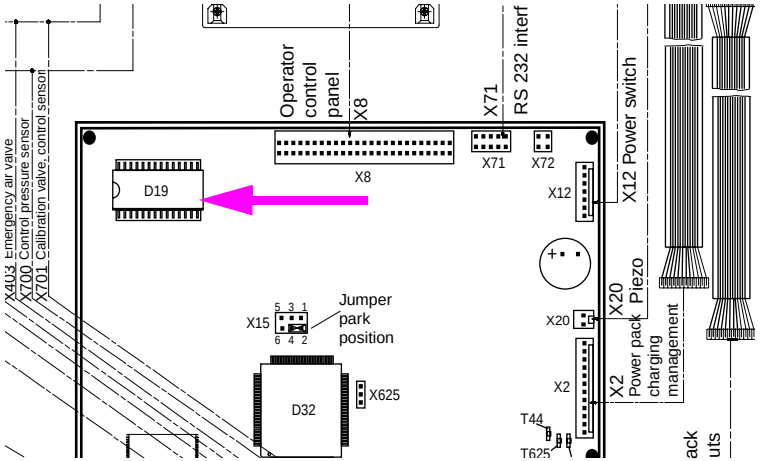

Fig.20: Removing the RTC

- Insert the brand-new RTC.
- Assemble the unit.
- Switch on the unit.

A device malfunction is generated.

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- Adjust settings (as written down), time, and date on the unit.
- Switch unit off and on again.

The unit should not generate any device malfunction. Settings recently made should be available. The operating hours should have the same status as before replacement of the RTC.

- Perform the safety check and functional check as per the Test Certificate.

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Service Mode

General

The Service Mode is mainly intended for troubleshooting and as a test aid for the Test Certificate.

The Service Mode allows you to call up different test steps. In these test steps, you can, for example, read out the error list, and check measured values and keys. The displayed plain text is in English. The functions of the test steps are described in the continuous text. Since valves are switched, we recommend to have a pneumatics diagram ready for better understanding (see Schematics and Diagrams section, "Pneumatic diagram").

– Entering the Internal Service Mode

– List of test steps

– Description of the test steps

– Required equipment

– Entering the PC Service Mode

– Exiting Service Mode

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Internal Service Mode

Entering the Internal Service Mode

1. Switch on Savina and, at the same time, press and hold the backlighting dim-up/dim-down key and the "Config" key until the service mode is activated.

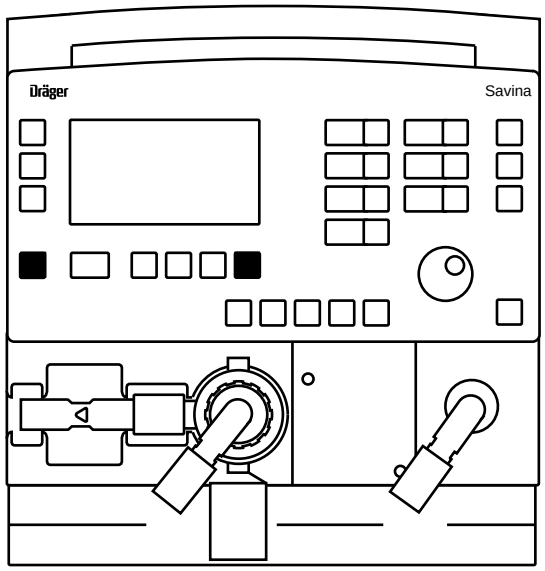

Fig.1: Entering the internal Service Mode

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The following screen page appears on the display:

Fig.2: Internal Service Mode start screen page

The individual test steps can be selected and activated with the control knob as follows:

1. Press the control knob.
   The "field" with the test step number becomes dark. The test step number is displayed in reverse video.

2. Turn the control knob.
   The desired test step number can be set.

3. Press the control knob.
   The selected test step is activated.

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Different settings can be made depending on the selected test step. The procedure is described in the following example:

1. Select test step 7.
   The following window appears:

Fig.3: Test step 7

The box with the "thicker" black frame is active. You can change the active box by turning the control knob. In this case the "Set blower revolution" box (blower speed) is active.

To change the blower speed:

1. Press the control knob.
   The box with the speed becomes dark. The speed is displayed in reverse video.

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2. Turn the control knob.
   The desired speed can now be set (if you do not wish to change the speed, use the "Alarm Reset" key to exit the respective setting).

3. Press the control knob.
   The blower turns at the set speed.

To exit the test step:

1. Turn the control knob until the "Exit" box is activated.

2. Press the control knob.
   The start screen page appears. The blower has stopped turning.

To exit the internal service mode:

1. Switch off Savina.

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List of test steps

Table 1: Test steps and description

Test step	Description
Test Step 0	Reading out the error log (error list).
Test Step 1	Testing keys.
Test Step 2	Testing keys.
Test Step 3	Displaying device and service operating hours.
Test Step 4	Displaying battery and power pack voltages.
Test Step 5	Switching valve block valves.
Test Step 6	Testing the O_2 pressure supply. As of SW 1.10, reading out of SW options.
Test Step 7	Testing the pressure source (blower) and the inspiratory sensor.
Test Step 8	Testing the O_2 measurement and the O_2 mixer.
Test Step 9	Testing the expiratory valve.
Test Step 10	Testing the safety valve.
Test Step 11	Testing the emergency air valves V8/V9.
Test Step 12	Testing the calibration valves for the airway pressure sensors.
Test Step 13	Testing the drug nebulizer valve.
Test Step 14	Testing the inspiratory and expiratory flow measurement.

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Table 1: Test steps and description (cont'd.)

Test step	Description
Test Step 15	Setting the calibration classes for the bypass valve (V1) and of the expiratory valve (V3).
Test Step 16	Displaying the internal device temperature.
Test Step 17	Displaying the internal, analog measured values of the master processor.
Test Step 18	— see Test Step 17 —
Test Step 19	Displaying the external, analog measured values of the master processor.
Test Step 20	Displaying the internal, analog measured values of the front processor.
Test Step 21	— see Test Step 20 —
Test Step 22	Displaying and calibrating the offset and calibration voltage of the electronics for the O_2 sensors.
Test Step 23	Calibrating the offset voltage of the inspiratory and expiratory pressure sensors.
Test Step 24	Displaying the calibration data of the O_2 sensors.
Test Step 25	— Up to SW 1.01, not assigned — as of SW 1.10, display of actual status of display, 7-segment display, and LEDs.
Test Step 26	— Up to SW 1.01, not assigned — as of SW 1.10, setting factory default values.
Test Step 27	Entering the ambient pressure.

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Description of the test steps

Test Step 0

Test step 0 is used to read out the error log (error list). A list of error messages appears. 5 error messages are visible at a time. Additional error messages can be viewed by scrolling. The error messages have the following structure:

First occurrence	Last occurrence	Error number	Number of errors

"Send Logbook" transmits the error log to a PC (for settings in the terminal program, see also"Entering the PC Service Mode"). "Delete Logbook" deletes the error log.
For assignment of error numbers, see chapter "Error List".

Test Step 1

Test steps 1 and 2 are used to test the keys on the front panel. The name of the key appears, e.g. "Nebulizer", and "Not press." (not pressed). "Pressed" is displayed as soon as the key is pressed. This method can be used to test all keys.

Test Step 2

— see Test Step 1 —

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Test Step 3

Test step 3 is used to display the device operating hours and the service hours. The service hours can be reset to zero with the "Reset service hours" function. Operating hours and service hours are not counted while the device is in standby.

Test Step 4

Test step 4 is used to display the operating voltages of the power pack (except for the +48 V for the blower) and the voltage of the internal battery. Moreover, the status of the external AC supply ”ext. AC-supply”, external DC supply ”ext. DC-supply” (on-board electrical system or external battery), internal battery ”int. battery”, and the charge status of the internal battery ”charge state" is displayed.

Display	Range	Display	Range
+5 V	+4.85 V to +5.53 V	+24 V	+22.8 V to +25.2 V
+15 V	+14.25 V to +15.75 V	int. battery	20 V to 28 V
-15 V	-14.25 V to -15.75 V		

Status	Key:
”ext. AC-supply” ”OK”	External AC voltage present.
”ext. AC-supply” ”NC”	External AC voltage not present or faulty.
”ext. DC-supply” ”OK”	External DC voltage present.

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Status ”ext. DC-supply” ”NC”	Key: External AC voltage not present or faulty.
"int. battery" "OK"	Internal battery is present.
"int. battery" "NC"	Internal battery is not present or is faulty.
"int. battery" "CHARGING"	Internal battery is present and is being charged.
"charge state"	0% to 100% internal battery capacity.

Test Step 5

Test step 5 is used to read out the O2 supply pressure ”O2-supply pressure” of the valve block and to switch each valve on the valve block (V7.1 through V7.8) individually. The valve can be switched on or off using the "Valve status" function. The respective valve can be selected using the "Valve" function. The switching noise of the valves is clearly audible. To perform a more accurate test, it is possible to connect a flowmeter tube to the valve block and to test each valve with the respective restrictor. The test values listed in the table apply to a supply pressure of the valve block of 2 bar ± 0.01 bar (with open valve).

Valve/restrictor	Restrictor value	Valve/restrictor	Restrictor value
V7.1/R5.1	30 L/min ±2 L/min	V7.5/R5.5	12 L/min ±1 L/min
V7.2/R5.2	30 L/min ±2 L/min	V7.6/R5.6	12 L/min ±1 L/min
V7.3/R5.3	30 L/min ±2 L/min	V7.7/R5.7	3.9 L/min ±0.3 L/min
V7.4/R5.4	30 L/min ±2 L/min	V7.8/R5.8	3.9 L/min ±0.3 L/min

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Test Step 6

Up to SW 1.01 -> Test step 6 is used to display the O2 supply pressure "O2-supply pressure" of the O_2 supply source (sensor S5). The pressure must be between 2.7 bar and 6 bar.

As of SW 1.10 -> Test step 6 shows the SW options available in Savina. A SW option can be deactivated with ”disable option”.

The option can only be reactivated using the correct ”release code”. The code must be entered in the ”Config.” menu with the unit set to ventilation mode.

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Test Step 7

The O_2 supply pressure must be disconnected in order to be able to perform test step 7.

The following measured values are displayed in test step 7:

– "Flowinsp" -> measured value of the inspiratory flow sensor S1

– "Pawinsp" -> measured value of the inspiratory pressure sensor S4.1

– "Blower revolution" -> speed of the blower

The speed of the blower can be changed with "Set blower revolution".

The bypass valve (V1) can be set with "Pressure bypass". 0 means the bypass valve is open. No pressure is built up. If the bypass valve is closed slightly, the corresponding pressure is built up and air flows out of the inspiratory socket. The pressure sensor S4.1 (Pawinsp) indicates a pressure. The expiratory valve is "sealed" with 30 mbar.

Test Step 8

Connect a hose system including breathing bag to the inspiratory socket and the expiratory socket to perform this test step.

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Test step 8 is used to display the inspiratory flow "Flowinsp", the O_2 concentration "O2 (sensor 1)" "O2 (sensor 2)" of the mixing chamber, and the O_2 supply pressure. In addition, each valve of the valve block can be switched individually. With "O2 valve status" the valve (V7.1 through V7.8) can be switched to "on", "off", or "pulsating" (100 ms "on", 200 ms "off). The respective valve can be selected using the "O2 valve" function. The switching noise of the valves is clearly audible. The expiratory valve is "sealed" with 10 mbar.

Test Step 9

Connect (short-circuit) the inspiratory socket and the expiratory socket with a ventilation hose to perform this test step.

Test step 9 is used to display the expiratory flow "Flowexp" (S2), the expiratory pressure "Pawexp" (S4.1), and the inspiratory pressure "Pawinsp" (S4.2). The expiratory pressure can be adjusted (V3). The blower generates a constant flow of 10 L/min.
Trigger expiratory valve with > 5 mbar. The following measured values should be displayed:

– ”Flowexp” = 10 L/min ±1 L/min

– ”Pawexp” = ”Pawinsp” ±1.5 mbar

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Test Step 10

Connect (short-circuit) the inspiratory socket and the expiratory socket with a ventilation hose and connect an external pressure measuring device to perform this test step.

Test step 10 is used to display the expiratory pressure "Pawexp" (S4.1) and the inspiratory pressure "Pawinsp" (S4.2). The maximum permissible pressure is 105 mbar. The external pressure measuring device indicates the opening pressure of the safety valve D1 (Target value = 102 mbar to 110 mbar).
The blower delivers a flow 30 L/min; the expiratory valve is "sealed" with 120 mbar.

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Test Step 11

Connect (short-circuit) the inspiratory socket and the expiratory socket with a ventilation hose and connect an external pressure measuring device to perform this test step.

Test step 11 is used to test the emergency air valves V8/V9. The valves can be switched on or off. This test step is also used to display the expiratory pressure "Pawexp" (S4.1) and the inspiratory pressure "Pawinsp" (S4.2).

V8/V9 off -> pressure reading approx. 94 mbar
V8/V9 on -> pressure reading maximum 5 mbar

A venting noise is clearly audible when the valves are switched to "on".

Test Step 12

Connect (short-circuit) the inspiratory socket and the expiratory socket with a ventilation hose to perform this test step.

Test step 12 is used to test the calibration valves (V6.1, V6.2) of the airway pressure sensors (S4.1, S4.2). The valves can be switched on or off. In addition, the inspiratory flow "Flowinsp", the inspiratory pressure "Pawinsp", and the expiratory pressure "Pawexp" are displayed. The following approximate values are displayed:

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"Insp.cal valve" (V6.1)	"Exp.cal valve" V6.2	"Flowinsp"	"Pawinsp"	"Pawexp"
on	off	10 L/min	0 mbar ±0.3 mbar	approx. 40 mbar
off	off	10 L/min	approx. 40 mbar	approx. 40 mbar
off	on	10 L/min	approx. 40 mbar	0 mbar ±0.3 mbar
on	on	10 L/min	0 mbar ±0.3 mbar	0 mbar ±0.3 mbar

Test Step 13

Test step 13 is used to test the nebulizer valve (V5). The valve can be switched on or off. When the valve is switched on, O2 flows out of the nebulizer socket (8 L/min +5 L/min). The nebulizer is powered with O2.

Test Step 14

Connect (short-circuit) the inspiratory socket and the expiratory socket with a ventilation hose to perform this test step.

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Test step 14 is used to check the correspondence between the inspiratory "Flowinsp" and the expiratory "Flowexp" flow measurement. The bypass valve (V1) can be set with "Pressure bypass". 0 means the bypass valve is open. No pressure is built up. When the bypass valve is closed, a corresponding pressure is built up (the expiratory valve is "sealed" with 30 mbar and air flows. Measured value: "Flowexp" = "Flowinsp" ±13% (from "Flowinsp")

Test Step 15

Incorrect calibration classes lead to ventilation errors. Calibration classes may only be changed during repair (see maintenance procedure, chapters "Bypass valve V1 and Expiratory valve V3").

Test step 15 is used to set the calibration classes of the bypass valve (V1) and of the expiratory valve (V3). "Bypass valve cal. class" is used to set the calibration class of the bypass valve; "Exp. valve cal. class" is used to set the calibration class of the expiratory valve.

Test Step 16

Test step 16 is used to display the internal device temperature in degree centigrade (°C) and Fahrenheit (°F). The temperature is measured with a temperature sensor located on the Control PCB. At normal ambient temperature, the internal device temperature is between 15 °C and 45 °C or 59 °F and 113 °F.

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Test Step 17

Test step 17 is used to display the measured value of the internal A/D converter of the master processor.

Designation	A/D values	Voltage range	Remark
V_FLOW_TEMP	0409 ... 0512	2.00 V ... 2.50 V	(at ambient temperature). Temperature of inspiratory gas, measured at TSI sensor (S1) assembly.
V_TEMP_AIR	0246 ... 0327	1.20 V ... 1.60 V	(at ambient temperature). Temperature of inspiratory gas. The temperature sensor (NTC) is located on the inspiration block. The measurement signal is processed on the O2 Diaphragm PCB.
VCC+15V_O2_MESS	0593 ... 0634	2.90 V ... 3.10 V	Measurement signal of the +15V supply voltage of the O2 Diaphragm PCB/O2 sensors.
VCC+15V_MESS	0573 ... 0655	2.80 V ... 3.20 V	Measurement signal of the +15V supply voltage.

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Designation	A/D values	Voltage range	Remark
VCC+5V_S_MESS	0491 ... 0532	2.40 V ... 2.60 V	Measurement signal of the +5V supply voltage of the absolute pressure sensors S6, S7. The voltage is generated on the O2 Valve PCB from the +15 V.
V_ABS_PRESS_1	0798 ... 0880	3.90 V ... 4.30 V	(at normal atmospheric pressure). Measurement signal of the absolute pressure sensor S7. The sensor is located on the O2 Valve PCB.
V_ABS_PRESS_2	0798 ... 0880	3.90 V ... 4.30 V	(at normal atmospheric pressure). Measurement signal of the absolute pressure sensor S6. The sensor is located on the O2 Valve PCB.
V_FIO2_2	0102 ... 0205	0.50 V ... 1.00 V	(if system is free from O2). Measurement signal of O2 sensor 2. The measurement signal is processed on the O2 Diaphragm PCB.

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Test Step 18

Test step 18 is used to display the measured value of the internal A/D converter of the master processor.

Designation	A/D values	Voltage range	Remark
V_FIO2_1	0102 ... 0205	0.50 V ... 1.00 V	(if system is free from O2). Measurement signal of O2 sensor 1. The measurement signal is processed on the O2 Diaphragm PCB.
V_O2_PRESSURE	0164 ... 0246	0.80 V ... 1.20 V	(O2 depends on supply pressure, disconnect O2 supply). O2 supply pressure, measured at S5. S5 is located on the O2 Valve PCB.
V_REF_O2	0593 ... 0634	2.90 V ... 3.10 V	Reference voltage for V_TEMP_AIR and V_TEMP_O2. The reference voltage is generated on the O2 Diaphragm PCB from the battery voltage.
V_PAW_REG	0123 ... 0184	0.60 V ... 0.90 V	Measurement signal of control pressure sensor S4.3. The sensor is only available in the first lot of units.

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Designation	A/D values	Voltage range	Remark
V_TEMP_AWT	1023	5.00 V	(without external AWT sensor). Measurement signal of AWT sensor. The measurement signal is processed on the Control PCB (temperature hybrid).
V_TEMP_AWT	0716 ... 0818	3.50 V ... 4.00 V	(with external AWT sensor, at ambient temperature).
V_FLOW	0004 ... 0012	0.02 V ... 0.06 V	(with flow exp. = 0). Flow signal of expiratory flow sensor S2.
V_FLOW_NULL	0822 ... 0831	4.02 V ... 4.06 V	(with flow exp. = 0). Signal of expiratory flow sensor S2.
V_FLOW_INOP	0102 ... 0246	0.50 V ... 1.20 V	Signal of expiratory flow sensor S2.

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Test Step 19

Test step 19 is used to display the measured value of the external A/D converter of the master processor.

Designation	A/D values	Voltage range	Remark
V_FLOW	0016 ... 0049	0.020 V ... 0.060 V	(with flow exp. = 0). Flow signal of expiratory flow sensor S2.
V_FLOW_INSP	0246 ... 0491	0.300 V ... 0.600 V	(with flow insp. = 0). Flow signal of inspiratory flow sensor S1.
V_PAW_INSP	0491 ... 0737	0.600 V ... 0.900 V	Measurement signal of the inspiratory pressure sensor S4.2.
V_PAW_EXP	0491 ... 0737	0.600 V ... 0.900 V	Measurement signal of the expiratory pressure sensor S4.1.
V_FIO2_1	0410 ... 0819	0.500 V ... 1.000 V	(if system is free from O2). Measurement signal of O2 sensor 1. The measurement electronics are located on the O2 Diaphragm PCB.
V_REF_O2	2375 ... 2539	2.900 V ... 3.100 V	Reference voltage for V_TEMP_AIR and V_TEMP_O2. The reference voltage is generated on the O2 Diaphragm PCB from the battery voltage.

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Designation	A/D values	Voltage range	Remark
V_TEMP_O2	0983 ... 1310	1.200 V ... 1.600 V	Temperature of O2 sensors. The temperature measurement is located on the O2 Diaphragm PCB.
V_TSI_GND	0000 ... 0004	0.000 V ... 0.005 V	Ground pick-up of inspiratory flow sensor S1.

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Test Step 20

Test step 20 is used to display the measured value of the internal A/D converter of the front processor.

Designation	A/D values	Voltage range	Remark
V_PAW_INSP	0123 ... 0184	0,60 V ... 0,90 V	Measurement signal of the inspiratory pressure sensor S4.2.
V_PAW_EXP	0123 ... 0184	0,60 V ... 0,90 V	Measurement signal of the expiratory pressure sensor S4.1.
V_FLOW	0004 ... 0012	0,02 V ... 0,06 V	(with flow exp. = 0). Flow signal of expiratory flow sensor S2.
V_FLOW_INSP	0061 ... 0123	0,30 V ... 0,60 V	(with flow insp. = 0). Flow signal of inspiratory flow sensor S1.
V_AKKU_MESS	0681 ... 0953	3,33 V ... 4,66 V	Measurement signal of internal battery voltage.
VCC+15V_MESS	0573 ... 0655	2,80 V ... 3,20 V	Measurement signal of the +15V supply voltage.
VCC-15V_MESS	0573 ... 0655	2,80 V ... 3,20 V	Measurement signal of the -15V supply voltage.
VCC+5V_MESS	0501 ... 0542	2,45 V ... 2,65 V	Measurement signal of the +15V supply voltage.

Test Step 21

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Test step 21 is used to display the measured value of the internal A/D converter of the front processor.

Designation	A/D values	Voltage range	Remark
VCC+24V_MESS	0655 ... 0737	3,20 V ... 3,60 V	Measurement signal of the +24V supply voltage.
VOP+15V_MESS	0573 ... 0655	2,80 V ... 3,20 V	Measurement signal of the +15V supply voltage for the control electronics of the bypass and expiratory valves.
VOP-15V_MESS	0573 ... 0655	2,80 V ... 3,20 V	see VOP+15V_MESS
SNGD_M	0002 ... 0010	0,01 V ... 0,05 V	Connected ground on Control PCB.
V_GOLD_CAP	0921 ... 1003	4,50 V ... 4,90 V	(charged). Voltage of Gold-Cap capacitor. Voltage is through-connected via contacts of ON/OFF switch. The capacitor is located on the Control PCB.
I_PIEZO_MESS	0000 ... 0008	0,00 V ... 0,04 V	Measurement signal of alarm generator.
V_TEMP_INT	0184 ... 0246	0,90 V ... 1,20 V	(at ambient temperature). Measurement signal for internal device temperature, measured at Control PCB.
V_SYNC_PIEZO	0000 ... 1023	0,00 V ... 5,00 V	(runs cyclically, due to silencing). Measurement signal for intermittent tone of alarm generator.

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Test Step 22

Test step 22 is used to display the "Measured offset voltage" and the "Calibrated offset voltage" of the electronics for the O_2 sensors. In addition, this test step can be used to calibrate the offset of the measurement electronics "Calibrate O2 sensors".

To calibrate the measurement electronics, remove the O_2 sensors. Refit O_2 sensors after calibration.

Select "Start" to start calibration. "Running" is displayed. Calibration is finished as soon as the message "Start" reappears.

Test Step 23

Test step 23 is used to display the offset voltages of the inspiratory pressure sensor (S4.1) and expiratory pressure sensor (S4.2). This test step is also used to calibrate the offset voltage. Activate "Calibrate" to start calibration. It is clearly audible when the respective valves (V6.1/V6.2) switch to ambient air.

Value after calibration: —75 mV to +75 mV

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Test Step 24

Test step 24 is used to display the following calibration data of the O_2 sensors (S3.1, S3.2):

"Cal.const"	Calibration constant
"Offset voltage"	Electronics offset voltage
"Pressure"	Pressure at which calibration was carried out
"Temperature"	Temperature at which calibration was carried out

Test Step 25

Up to SW 1.01 -> not assigned.

As of SW 1.10 -> Test step 25 is used to test the LC display, the LEDs, and the 7-segment displays. The following tests can be called up with ”Test target”:

– ”LED”: All LEDs can be switched on and off (LEDs for indication of voltage supply are not triggered, they come on depending on voltage supply and charge state of the battery).

– ”LCD”: The display is switched to ”dark” for 5 seconds, then to ”bright” for 5 seconds.

– ”7-segment”: 7-segment displays, including decimal point, can be switched on and off.

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Test Step 26

Up to SW 1.01 -> not assigned.

As of SW 1.10 -> Test step 26 is used to set all values to factory default settings. Adjustment can be done with ”Set factory settings”.

Test Step 27

Before adjusting the ambient pressure, disconnect the O_2 supply.

Test step 27 is used to set the ambient pressure for calibration of pressure sensors S6, S7, and S5. The ambient pressure must be measured with an external barometer. The following measured values are displayed (after calibration -> enter and confirm ambient pressure):

Measured value S7 -> "Ambient pressure (S7)" ambient pressure entered ±2 mbar
Measured value S6 -> "Ambient pressure (S6)" ambient pressure entered ±2 mbar
Measured value S5 -> "O2 supply pressure" ambient pressure entered ±20 mbar

The measured values are kept even after the unit is switched off (stored in the EEPROM).

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PC Service Mode

The PC service mode applies to software version 1.96 only.

Required equipment

The following equipment is required to work with service mode:

– RS 232 extension 7901808

– RS 232 adapter 7901888

– Service PC (laptop) with terminal program (Hyperterminal)

The terminal program (Hyperterminal) is normally installed on the Service PC. You will find the terminal program under Start/Programs/Accessories/Hyperterminal/Hyperterminal.

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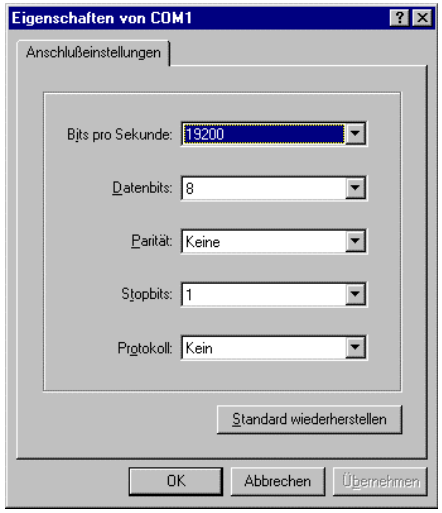
Entering the PC Service Mode

- Connect Savina and PC (laptop) to mains power supply.
- Switch on the PC.
- Start terminal program.
- Select relevant COM port (here: COM 1).
- Make the following settings in the terminal program:

  – Baud rate: 19200
  – Data bits: 8
  – Parity: None
  – Stop bits: 1
  – Protocol: None



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- Connect PC and Savina to RS232 extension and to RS232 adapter.
- Switch Savina on, at the same time pressing and holding down the key to lighten/darken the screen backlighting, and press the "Config" key.

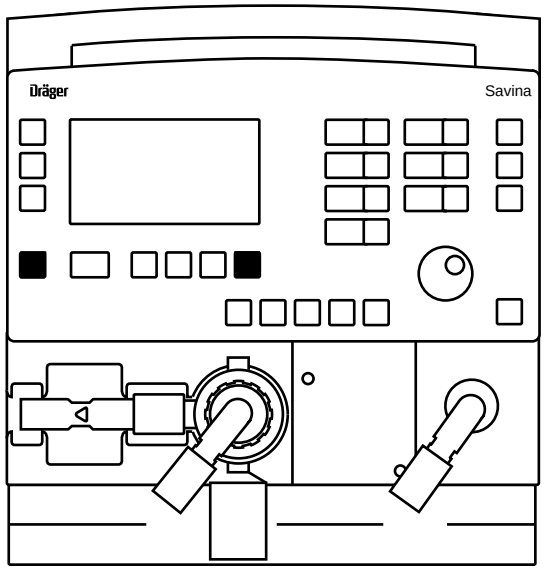

Fig.4: Entering Service Mode

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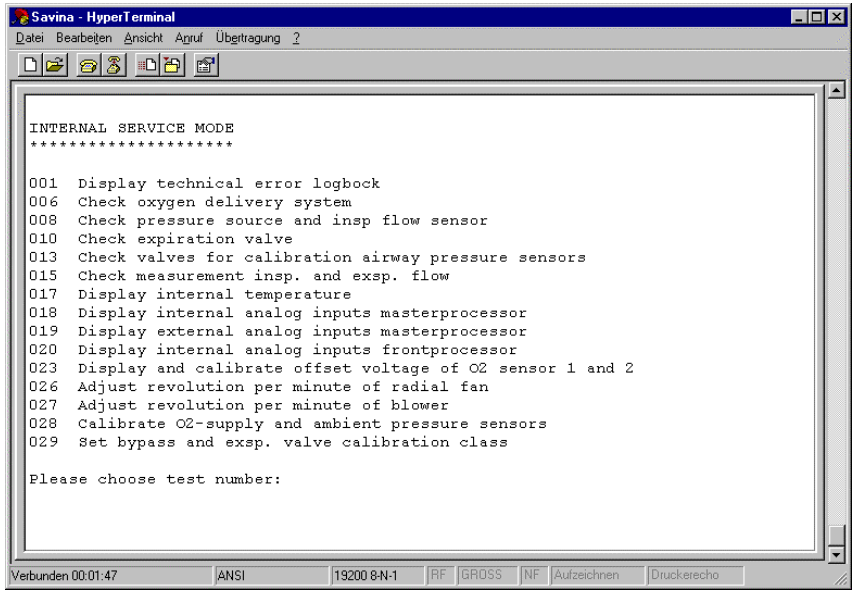
Savina starts up with Service Mode on the display. A contents list of the available tests is displayed on the PC.


Savina - HyperTerminal
Datei Bearbeiten Ansicht Anruf Übertragung ?
INTERNAL SERVICE MODE
****
001 Display technical error logbock
006 Check oxygen delivery system
008 Check pressure source and insp flow sensor
010 Check expiration valve
013 Check valves for calibration airway pressure sensors
015 Check measurement insp. and exsp. flow
017 Display internal temperature
018 Display internal analog inputs masterprocessor
019 Display external analog inputs masterprocessor
020 Display internal analog inputs frontprocessor
023 Display and calibrate offset voltage of O2 sensor 1 and 2
026 Adjust revolution per minute of radial fan
027 Adjust revolution per minute of blower
028 Calibrate O2-supply and ambient pressure sensors
029 Set bypass and exsp. valve calibration class
Please choose test number:
Verbunden 00:01:47
ANSI
19200 8-N-1
RF
GROSS
NF
Aufzeichnen
Druckerecho

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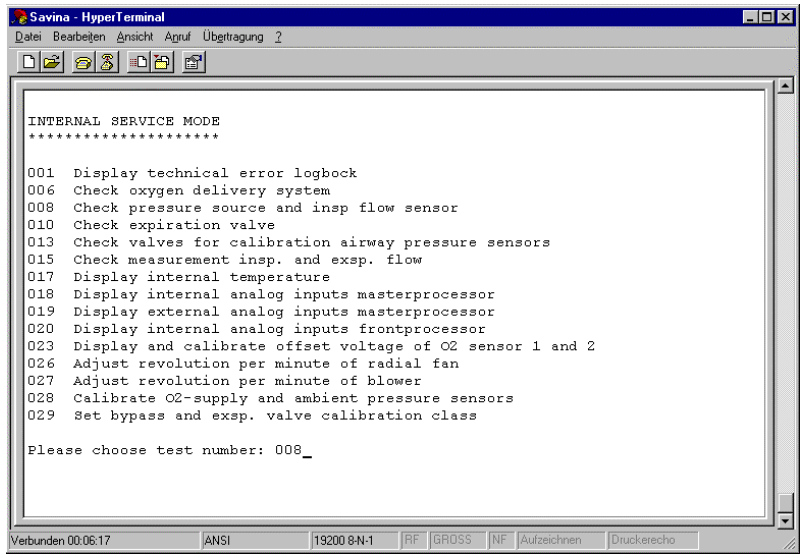
When the test number is entered the corresponding test is called up (here: test 008).


Savina - HyperTerminal
Datei Bearbeiten Ansicht Anruf Übertragung ?
INTERNAL SERVICE MODE
****
001 Display technical error logbock
006 Check oxygen delivery system
008 Check pressure source and insp flow sensor
010 Check expiration valve
013 Check valves for calibration airway pressure sensors
015 Check measurement insp. and exsp. flow
017 Display internal temperature
018 Display internal analog inputs masterprocessor
019 Display external analog inputs masterprocessor
020 Display internal analog inputs frontprocessor
023 Display and calibrate offset voltage of O2 sensor 1 and 2
026 Adjust revolution per minute of radial fan
027 Adjust revolution per minute of blower
028 Calibrate O2-supply and ambient pressure sensors
029 Set bypass and exsp. valve calibration class
Please choose test number: 008
Verbunden 00:06:17
ANSI
19200 8-N-1
RF
GROSS
NF
Aufzeichnen
Druckerecho

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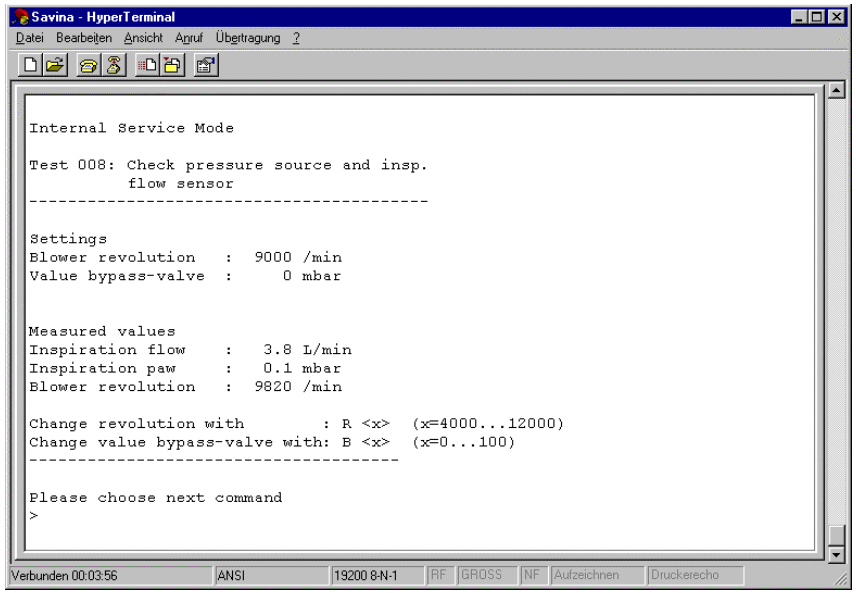
The test indicates which settings can be made.



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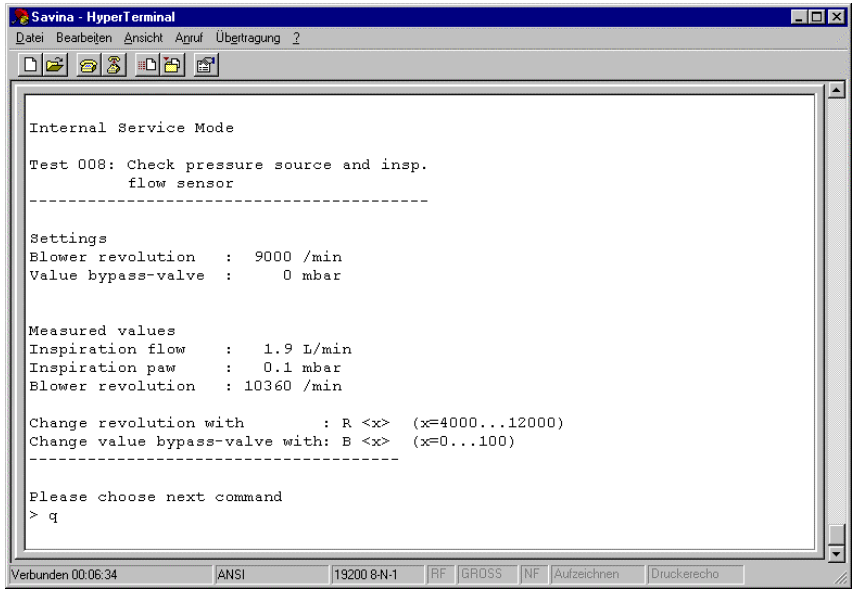
Quit the selected test by entering the letter "q".



Exiting Service Mode

Exit Service Mode by switching off the Savina. The next time the Savina is switched on it starts up with the pre-set ventilation mode.

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Error List

Structure of error list

The error code is divided into a 2-digit decimal number and a 4-digit decimal number. The 2-digit decimal number indicates which component/assembly is affected. The 4-digit decimal number is a more detailed specification for the software as to the malfunction suffered by the component/assembly concerned.

Example:

Error code	Description of malfunction	Possible remedy
42.0000	Rotation speed too low.	Replace the blower.

The "42" indicates that the error relates to the blower. The "0000" indicates that the rotation speed is too low. The "malfunction description" is not always described in plain text, since it in some cases involves names of software routines. "Possible remedy" shows the possible defective assembly or a reference to other remedies.

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The following abbreviations are used:

– MP = master processor,

– FP = front processor,

– SW = software,

– SiSW = safety software,

– RTC = real-time clock,

– DS = DrägerService.

Software master processor (MP) error group

Error code	Description of malfunction	Possible remedy
00.0001	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0002	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0010	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0011	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0012	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0100	Device reset triggered: SW error.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
00.0200	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0300	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0400	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0401	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0402	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0500	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0501	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0600	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0601	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0602	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0603	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0700	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0701	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0800	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0801	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0802	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.0900	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1000	Device reset triggered: SW error.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
00.1100	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1101	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1200	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1300	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1301	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1302	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1303	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1400	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1401	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1500	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1600	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1610	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1700	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1800	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1900	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.1910	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.2000	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.2010	Device reset triggered: SW error.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
00.2020	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.2100	Device reset triggered: SW error.	– Report error to DS Lübeck.
00.2110	Device reset triggered: SW error.	– Report error to DS Lübeck.

Master processor (MP) read-only memory error group 01

Error code	Description of malfunction	Possible remedy
01.0000	ROM test: Checksum procedure test not OK.	– Carry out SW download using current SW. – Replace Control PCB.
01.0100	ROM test: Error found during checksum start test.	– Carry out SW download using current SW. – Replace Control PCB.
01.0101	ROM test: Error found during current checksum test.	– Carry out SW download using current SW. – Replace Control PCB.
01.0200	Data retention: Read error.	– Replace Control PCB.
01.0201	Data retention: Write error.	– Replace Control PCB.

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Error code	Description of malfunction	Possible remedy
01.0300	Data retention (EEPROM), checksum error: Data structure EEPROM (Magic).	– Complete data input in EEPROM MP (see error codes 01.0301 through 01.0314) – Replace Control PCB.
01.0301	Data retention (EEPROM), checksum error: Bypass valve.	– Resetting of calibration class for bypass valve in Service Mode, test 15. – Replace Control PCB.
01.0302	Data retention (EEPROM), checksum error: Expiratory valve.	– Resetting of calibration class for expiratory valve in Service Mode, test 15. – Replace Control PCB.
01.0303	Data retention (EEPROM), checksum error: Blower start speed (not used for the time being).	–
01.0304	Data retention (EEPROM), checksum error: Fan start speed (not used for the time being).	–
01.0305	Data retention (EEPROM), checksum error: Correction for leak in blower (not used for the time being).	–

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Error code	Description of malfunction	Possible remedy
01.0306	Data retention (EEPROM), checksum error: Spirolog sensor (not used for the time being).	–
01.0307	Data retention (EEPROM), checksum error: Offset of O2 sensor 1.	– Carry out Service Mode, test 22. – Replace Control PCB.
01.0308	Data retention (EEPROM), checksum error: Calibration of O2 sensor 1.	– Switch the unit off/on. O2 sensor 1 calibrated after power-on. – Replace Control PCB.
01.0309	Data retention (EEPROM), checksum error: Offset of O2 sensor 2.	– Carry out Service Mode, test 22. – Replace Control PCB.
01.0310	Data retention (EEPROM), checksum error: Calibration of O2 sensor 2.	– Calibrate O2 sensor 2 (menu "Config" "O2 calib."). – Replace Control PCB.
01.0311	Data retention (EEPROM), checksum error: Calibration of O2 supply pressure sensor S5 , ambient pressure sensors S6 and S7.	– Carry out Service Mode, test 27 (calibration of ambient pressure sensors).

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Error code	Description of malfunction	Possible remedy
01.0312	Data retention (EEPROM), checksum error: Pneumatics variant (not used for the time being).	–
01.0313	Data retention (EEPROM), checksum error (not used for the time being).	–
01.0314	Data retention (EEPROM), checksum error (not used for the time being).	–
01.1000	Faulty values from data retention: Fan.	– see 01.0304.
01.1010	Faulty values from data retention: Blower.	– see 01.0303.
01.1020	Faulty values from data retention: Bypass valve calibration class.	– see 01.0301.
01.1030	Faulty values from data retention: Expiratory valve calibration class.	– see 01.0302.
01.1040	Faulty values from data retention: Offset of O2 sensor 1.	– see 01.0307.
01.1041	Faulty values from data retention: Calibration of O2 sensor 1.	– see 01.0308.
01.1050	Faulty values from data retention: Offset of O2 sensor 2.	– see 01.0309.

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Error code	Description of malfunction	Possible remedy
01.1051	Faulty values from data retention: Calibration of O2 sensor 2.	– see 01.0310.
01.2000	Data structure in EEPROM older than newly installed SW.	– Disappears after new power-on.
01.2001	Data structure in EEPROM newer than installed SW.	– Disappears after new power-on. – see 01.0300. – Carry out SW download using current SW.

Master processor (MP) RAM error group 02

Error code	Description of malfunction	Possible remedy
02.0000	Memory test: Error in the internal RAM.	– Replace Control PCB.
02.0100	Memory test: Error in the external RAM.	– Replace Control PCB.

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Internal AD converter software (MP) error group 03

Error code	Description of malfunction	Possible remedy
03.0000	Device reset triggered: SW error.	– Report error to DS Lübeck.
03.0001	Device reset triggered: SW error.	– Report error to DS Lübeck.
03.0002	Device reset triggered: SW error.	– Report error to DS Lübeck.
03.0003	Device reset triggered: SW error.	– Report error to DS Lübeck.
03.0004	Device reset triggered: SW error.	– Report error to DS Lübeck.
03.0005	Device reset triggered: SW error.	– Report error to DS Lübeck.

Internal communication software (MP) error group 04

Error code	Description of malfunction	Possible remedy
04.0000	Device reset triggered: SW error.	– Report error to DS Lübeck.
04.0100	Device reset triggered: SW error.	– Report error to DS Lübeck.
04.0101	Device reset triggered: SW error.	– Report error to DS Lübeck.
04.0102	Device reset triggered: SW error.	– Report error to DS Lübeck.
04.0103	Device reset triggered: SW error.	– Report error to DS Lübeck.
04.0104	Device reset triggered: SW error.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
04.0105	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0106	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0107	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0200	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0201	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0202	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0203	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0204	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0205	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0206	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0300	Device reset triggered: SW error	– Report error to DS Lübeck.
04.0400	Device reset triggered: SW error	– Report error to DS Lübeck.

Watchdog (MP) error group 05

Error code	Description of malfunction	Possible remedy
05.0000	Watchdog is defective.	– Replace Control PCB.

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Front processor (FP) software error group 10

Error code	Description of malfunction	Possible remedy
10.0100	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0101	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0200	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0300	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0301	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0302	Device reset triggered: SW error.	– Reset date and year. – Carry out SW update ≤1.10. – Control PCB or RTC faulty.
10.0400	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0500	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0600	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0601	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0602	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0800	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0810	Device reset triggered: SW error.	– Report error to DS Lübeck.
10.0900	Device reset triggered: SW error.	– Report error to DS Lübeck.

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ROM front processor (FP) error group 11

Error code	Description of malfunction	Possible remedy
11.0000	ROM test: Checksum test procedure faulty.	– Carry out SW download using current SW. – Replace Control PCB.
11.0100	ROM test: Error found during checksum start test.	– Carry out SW download using current SW. – Replace Control PCB.
11.0101	ROM test: Error found during current checksum test.	– Carry out SW download using current SW. – Replace Control PCB.
11.0200	Data retention: Read access error.	– Replace EEPROM FP. – Replace RTC.
11.0201	Data retention: Write access error.	– Replace EEPROM FP. – Replace RTC.
11.0300	Data retention (EEPROM), checksum error: Operating minutes storage.	– Switch on Savina again. – Replace EEPROM FP.

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Error code	Description of malfunction	Possible remedy
11.0301	Data retention (EEPROM), checksum error: Data structure in EEPROM (Magic).	– Complete new data input in EEPROM MP (see error codes 11.0300 and 11.0302 through 11.0306). – Replace EEPROM FP.
11.0302	Data retention (EEPROM), checksum error: Software options (not used for the time being).	–
11.0303	Data retention (EEPROM), checksum error: DeviceID (not used for the time being).	–
11.0304	Data retention (EEPROM), checksum error: Settings:	– Resetting of language version under "Config". – Replace EEPROM FP.
11.0305	Data retention (EEPROM), checksum error: Safety parameters.	– Switch on Savina again. – Replace EEPROM FP.
11.0306	Data retention (EEPROM), checksum error: Power pack variant (not used for the time being).	–

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Error code	Description of malfunction	Possible remedy
11.0307	Data retention (RTC-RAM), checksum error: Operating minutes.	– Switch on Savina again. – Replace RTC.
11.0308	Data retention (RTC-RAM), checksum error: Data structure in RTC-RAM (Magic).	– Complete new data input in RTC-RAM (see error codes 11.0307 and 11.0309 through 11.0314). – Replace RTC.
11.0309	Data retention (RTC-RAM), checksum error: System status.	– Press key to set display to bright/dark. – Replace RTC.
11.0310	Data retention (RTC-RAM), checksum error: Settings:	– Resetting of parameter "Vt". – Replace RTC.
11.0311	Data retention (RTC-RAM), checksum error: Safety parameters.	– Switch on Savina again. – Replace RTC.
11.0312	Data retention (RTC-RAM), checksum error: Buffer.	– Switch on Savina again. – Replace RTC.
11.0313	Data retention (RTC-RAM), checksum error: Buffer value.	– Switch on Savina again. – Replace RTC.

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Error code	Description of malfunction	Possible remedy
11.0314	Data retention (RTC-RAM), checksum error: Buffer address.	– Switch on Savina again. – Replace RTC.
11.2000	Data structure in EEPROM older than installed SW.	– Disappears after new power-on.
11.2001	Data structure in EEPROM newer than installed SW.	– Disappears after new power-on. – See 11.0301. – Carry out SW download using more current SW.
11.2002	Operating and service hours cannot be determined: Reset to zero!	– Data on EEPROM FP and RTC-RAM are incorrect at the same time, therefore the operating hours were reset to zero. Device is otherwise ready for use.

RAM front processor (FP) error group 12

Error code	Description of malfunction	Possible remedy
12.0000	Memory test: Error in the internal RAM.	– Replace Control PCB.

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Error code	Description of malfunction	Possible remedy
12.0100	Memory test: Error in the external RAM.	– Replace Control PCB.

Internal AD converter software (FP) error group 13

Error code	Description of malfunction	Possible remedy
13.0000	Device reset triggered: SW error.	– Report error to DS Lübeck.
13.0001	Device reset triggered: SW error.	– Report error to DS Lübeck.
13.0002	Device reset triggered: SW error.	– Report error to DS Lübeck.
13.0003	Device reset triggered: SW error.	– Report error to DS Lübeck.
13.0004	Device reset triggered: SW error.	– Report error to DS Lübeck.
13.0005	Device reset triggered: SW error.	– Report error to DS Lübeck.

Internal communication software (MP) error group 14

Error code	Description of malfunction	Possible remedy
14.0000	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0100	Device reset triggered: SW error.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
14.0101	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0102	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0103	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0104	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0105	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0106	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0107	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0200	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0201	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0202	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0203	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0204	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0205	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0206	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0300	Device reset triggered: SW error.	– Report error to DS Lübeck.
14.0400	Device reset triggered: SW error.	– Report error to DS Lübeck.

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Watchdog (FP) error group 15

Error code	Description of malfunction	Possible remedy
15.0000	Watchdog is defective.	– Replace Control PCB.

Software FP and MP error group 20

Error code	Description of malfunction	Possible remedy
20.0000	Device reset triggered: SW error.	– Report error to DS Lübeck.
20.0001	Device reset triggered: SW error.	– Report error to DS Lübeck.
20.0002	Device reset triggered: SW error.	– Report error to DS Lübeck.
20.0003	Device reset triggered: SW error.	– Report error to DS Lübeck.
20.0100	Device reset triggered: SW error.	– Report error to DS Lübeck.
20.0300	Device reset triggered: SW error.	– Report error to DS Lübeck.
20.0301	Device reset triggered: SW error.	– Report error to DS Lübeck.
20.0302	Device reset triggered: SW error.	– Report error to DS Lübeck.
20.0303	Device reset triggered: SW error.	– Report error to DS Lübeck.
20.0304	Device reset triggered: SW error.	– Report error to DS Lübeck.
20.0400	SiSW: Boot sequence is disturbed.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
20.0401	SiSW: Boot sequence is incorrect.	– Report error to DS Lübeck.
20.0402	SiSW: Boot variables are incorrect.	– Report error to DS Lübeck.
20.0500	SiSW: Time basis is faulty.	– Report error to DS Lübeck.

RTC error group 30

Error code	Description of malfunction	Possible remedy
30.0000	RTC battery flat.	– Replace RTC.
30.0100	Checksum error: Log.	– Call up Service Mode, test 0, and carry out "Delete log" function.
30.2000	Data structure (Magic) in RTC-RAM older than code.	– Disappears after new power-on.
30.2001	Data structure (Magic) in RTC-RAM newer than code.	– Disappears after new power-on. – See 11.0308. – Carry out SW download using current SW.

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Power pack error group 40

Error code	Description of malfunction	Possible remedy
40.0000	Power switch defective.	– Check power switch and cable harness. – Check connection to connector X12 on Control PCB. – Replace power switch. – See also ”Unit cannot be switched off” in chapter ”Repair Information/Error Events”.
40.0010	DC internal defective.	– Savina does not recognize the internal battery due to complete discharge, therefore pre-charge the internal battery using an external charger (see also ”Warning message "!!! No int. battery"” in chapter ”Repair Information/Error Events”). – Install new internal battery.

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Error code	Description of malfunction	Possible remedy
40.0011	DC internal is not being charged.	– May occur at extremely high ambient temperatures. Expose device to lower ambient temperatures. – See also error code "40.0010 – Install new internal battery.
40.0012	DC internal interrupted.	– Check fuse for internal battery. – Check cable connection from internal battery to power pack. – Check cable connection positive terminal of internal battery 1 to negative terminal of internal battery 2. – See also error code "40.0010
40.0013	Internal direct voltage is too low.	– See also error code "40.0010
40.1010	AD converter in power pack is faulty.	– Replace power pack. – See also error code "40.0010
40.1020	Power pack is faulty.	– Replace power pack. – See also error code "40.0010

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Error code	Description of malfunction	Possible remedy
40.1030	Power pack is no longer electrically safe.	– Replace power pack. – Voltage of internal battery is greater than 30 V. Replace internal battery. – External DC voltage is greater than 15.8 V. The problem could be due to two completely discharged external batteries, that is the power pack only detects one battery. Disconnect external battery and recharge or disconnect and reconnect batteries. – External DC voltage is greater than 31.8 V. Replace external batteries. – Check internal and external batteries. Replace power pack, if necessary.
40.1100	Communication (1) between power pack and Control PCB is faulty.	– Could be due to a log error after fast change of status. Power Savina from mains supply. – Replace power pack.

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Error code	Description of malfunction	Possible remedy
40.1110	Communication (2) between power pack and Control PCB is faulty.	– Could be due to a log error after fast change of status. Power Savina from mains supply. – Replace power pack.
40.1120	Communication (3) between power pack and Control PCB is faulty.	– Could be due to a log error after fast change of status. Power Savina from mains supply. – Replace power pack.

Operating voltages error group 41

Error code	Description of malfunction	Possible remedy
41.0000	Operating voltage +15 V is too low.	– Measure the operating voltage +15 V (see "Repair Procedure Measuring the supply voltages").
41.0001	Operating voltage +15 V is too high.	– Measure the operating voltage +15 V (see "Repair Procedure Measuring the supply voltages").

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Error code	Description of malfunction	Possible remedy
41.0010	Operating voltage —15 V is too low.	– Measure the operating voltage —15 V (see "Repair Procedure Measuring the supply voltages").
41.0011	Operating voltage —15 V is too high.	– Measure the operating voltage —15 V (see "Repair Procedure Measuring the supply voltages").
41.0020	Operating voltage +5 V is too low.	– Measure the operating voltage +5 V (see "Repair Procedure Measuring the supply voltages").
41.0021	Operating voltage +5 V is too high.	– Measure the operating voltage +5 V (see "Repair Procedure Measuring the supply voltages").
41.0030	Operating voltage +24 V is too low.	– Measure the operating voltage +24 V (see "Repair Procedure Measuring the supply voltages").
41.0031	Operating voltage +24 V is too high.	– Measure the operating voltage +24 V (see "Repair Procedure Measuring the supply voltages").

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Error code	Description of malfunction	Possible remedy
41.0040	Operating voltage +5 V of the ambient pressure sensors is too low.	– Operating voltage +15 V present (see "Repair Procedure Measuring the supply voltages")? – Operating voltage +15 V for O2 supply pressure sensor on O2 Valve PCB present (test point T2(+) and T9 (AGND1) on the O2 Valve PCB, see also chapter "Schematics and Diagrams O2 Valve PCB")? – Operating voltage +5 V for O2 ambient pressure sensors on O2 Valve PCB present (test point T7(+) and T9 (AGND1) on the O2 Valve PCB, see also chapter "Schematics and Diagrams O2 Valve PCB")? – Replace the O2 Valve PCB.

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Error code	Description of malfunction	Possible remedy
41.0041	Operating voltage +5 V of the ambient pressure sensors is too high.	– Operating voltage +15 V present (see "Repair Procedure Measuring the supply voltages")? – Operating voltage +15 V for O2 supply pressure sensor on O2 Valve PCB present (test point T2(+) and T9 (AGND1) on the O2 Valve PCB, see also chapter "Schematics and Diagrams O2 Valve PCB")? – Operating voltage +5 V for O2 ambient pressure sensors on O2 Valve PCB present (test point T7(+) and T9 (AGND1) on the O2 Valve PCB, see also chapter "Schematics and Diagrams O2 Valve PCB")? – Replace the O2 Valve PCB.
41.0050	Operating voltage +15 V detected as incorrect by SiSW.	– Operating voltage +15 V present (see "Repair Procedure Measuring the supply voltages")?

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Error code	Description of malfunction	Possible remedy
41.0060	Operating voltage +15 V of O2 sensors is faulty.	– Operating voltage +15 V present (see "Repair Procedure Measuring the supply voltages")? – Operating voltage +15 V for O2 sensors on O2 Diaphragm PCB present (test point X4/14(+) and X4/17 (AGND) on the O2 Diaphragm PCB, see also chapter "Schematics and Diagrams O2 DiaphragmPCB")? – Replace the O2 Diaphragm PCB. – Carry out SW update ≤1.10.

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Error code	Description of malfunction	Possible remedy
41.0070	Reference voltage of the O2 sensors is faulty.	– Operating voltage +15 V present (see "Repair Procedure Measuring the supply voltages")? – Operating voltage +15 V for O2 sensors on O2 Diaphragm PCB present (test point X4/14(+) and X4/17 (AGND) on the O2 Diaphragm PCB, see also chapter "Schematics and Diagrams O2 DiaphragmPCB")? – Replace the O2 Diaphragm PCB.
41.0100	Monitoring of lower limit of operating voltage +5 V is faulty, detected by SiSW.	– See error code 410020.
41.0101	Monitoring of upper limit of operating voltage +5 V is faulty, detected by SiSW.	– See error code 410021.

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Blower error group 42

Error code	Description of malfunction	Possible remedy
42.0000	Actual speed of blower is too slow.	– In new device it may occur that the blower is not fully run in which could lead to this sporadic error. – Replace the blower.
42.0001	Actual speed of blower is too fast.	– In new device it may occur that the blower is not fully run in which could lead to this sporadic error. – Replace the blower.
42.0002	Deviation between set and actual speed.	– In new device it may occur that the blower is not fully run in which could lead to this sporadic error. – Replace the blower.
42.0100	Micro-filter not fitted (switch is open).	– Micro-filter not fitted or not fitted correctly. – Switch behind the micro-filter is faulty.
42.0110	Resistance of the micro-filter is too high (not used for the time being).	–

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Error code	Description of malfunction	Possible remedy
42.0120	Micro-filter blocked (not used for the time being).	–
42.0130	Micro-filter obstructed (detected by SiSW).	– Replace the micro-filter.
42.0200	Error with speed adaptation detected by SW.	– Report error to DS Lübeck.
42.0210	Speed limited due to high ambient temperatures.	– Expose device to lower ambient temperatures.

Cooling error group 43

Error code	Description of malfunction	Possible remedy
43.0000	Internal temperature of device above 60 °C.	– Expose device to lower ambient temperatures. – Check whether power pack fan and device fan are functioning properly.
43.0010	Device internal temperature sensor: Short-circuit.	– Replace Control PCB.

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Error code	Description of malfunction	Possible remedy
43.0011	Device internal temperature sensor: Open circuit.	– Replace Control PCB.
43.0100	Device fan: Actual speed is too slow.	– Replace device fan.
43.0101	Device fan: Actual speed is too fast.	– Replace device fan.
43.0102	Device fan: Set/actual speed difference is too high.	– Replace device fan.
43.0103	Device fan: Deviation is too high.	– Replace device fan.
43.0110	Device fan is too slow (detected by SiSW).	– Replace device fan. – Report error to DS Lübeck.
43.0120	Device fan measuring electronics is faulty (detected by SiSW).	– Replace device fan. – Report error to DS Lübeck.

System relief error group 44

Error code	Description of malfunction	Possible remedy
44.0000	Inspiratory emergency venting is faulty.	– Check the emergency vent valves V8/V9.

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Error code	Description of malfunction	Possible remedy
44.0001	SW error in inspiratory emergency venting.	– Report error to DS Lübeck.

Loudspeaker error group 50

Error code	Description of malfunction	Possible remedy
50.0000	Audible alarm absent.	– Check loudspeaker connection to Frontpanel PCB. – Replace the loudspeaker.
50.0001	Loudspeaker sounds too often.	– Check loudspeaker connection to Frontpanel PCB. – Replace the loudspeaker. – Carry out SW update ≤1.10.
50.0002	Loudspeaker sounds too infrequently	– Check loudspeaker connection to Frontpanel PCB. – Replace the loudspeaker. – Carry out SW update ≤1.10.

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GoldCap error group 51

Error code	Description of malfunction	Possible remedy
51.0000	GoldCap capacity is too low.	– Replace Control PCB.
51.0001	GoldCap test device is faulty.	– Replace Control PCB.
51.0002	GoldCap power supply is too high.	– Replace Control PCB. – Carry out SW update ≤1.10.
51.0003	GoldCap power supply is too low.	– Replace Control PCB.
51.0004	GoldCap resistance is too high.	– Replace Control PCB.

Auxiliary alarm error group 54

Error code	Description of malfunction	Possible remedy
54.0000	Test current for signal generator (piezo) is too high.	– Check connection between signal generator and Control PCB. – Replace the signal generator. – Replace Control PCB.

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Error code	Description of malfunction	Possible remedy
54.0001	Test current for signal generator (piezo) is too low.	– Check connection between signal generator and Control PCB. – Replace the signal generator. – Replace Control PCB.

Airway pressure measurement error group 60

Error code	Description of malfunction	Possible remedy
60.0000	Inspiratory airway pressure sensor S 4.1: Calibration error.	– Check connection from solenoid and airway pressure sensor to the Control PCB. – See Service Mode, test 19: Replace pressure sensor S4.1 if test 19 fails. Replace solenoid V6.1 if test 19 is OK.

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Error code	Description of malfunction	Possible remedy
60.0001	Inspiratory airway pressure sensor S4.1: Measured value is outside the measuring range.	– Pressure applied to the airway pressure sensor was outside the range of —10 to +110 mbar. – Check connection from solenoid and airway pressure sensor to the Control PCB.
60.0002	Inspiratory airway pressure sensor S4.1: Deviation between maximum and minimum value is too small.	– Check connection from solenoid and airway pressure sensor to the Control PCB. – Remove stenosis in hose of supply to airway pressure sensor.
60.0010	Expiratory airway pressure S 4.2: Calibration error.	– Check connection from solenoid and airway pressure sensor to the Control PCB. – See Service Mode, test 19: Replace expiratory pressure sensor S4.2 if test 19 fails. Replace solenoid V6.2 if test 19 is OK.

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Error code	Description of malfunction	Possible remedy
60.0011	Inspiratory airway pressure sensor S4.2: Measured value is outside the measuring range.	– Pressure applied to the airway pressure sensor was outside the range of —10 to +110 mbar. – Check connection from solenoid and airway pressure sensor to the Control PCB.
60.0012	Inspiratory airway pressure sensor S4.2: Deviation between maximum and minimum value is too small.	– Check connection from solenoid and airway pressure sensor to the Control PCB. – Remove stenosis in hose of supply to airway pressure sensor.
60.0020	Calibration error S 4.3 (not used for the time being).	–
60.0021	Measured value S 4.3 outside of measuring range (not used for the time being).	–
60.0100	Deviation between inspiratory and expiratory airway pressure is too large (not used for the time being).	–

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Error code	Description of malfunction	Possible remedy
60.0200	Calculated airway pressure (Y-Paw): Invalid measured value.	– Sequence error, see error codes 60.0000 through 60.0012.
60.0300	Calculated inspiratory airway pressures of FP and MP deviate too much.	– Sequence error, see error codes 60.0000 through 60.0012.
60.0310	Deviation between inspiratory airway pressure and flow-corrected expiratory airway pressure is too large.	– Sequence error, see error codes 60.0000 through 60.0012.

Expiratory flow measurement error group 61

Error code	Description of malfunction	Possible remedy
61.0000	Sensor open wire.	– Check connection between Spirolog sensor and Control PCB. – Replace Spirolog sensor.
61.0001	Measured value is outside specification.	– Replace Spirolog sensor. – Check connection between Spirolog sensor and Control PCB.

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Error code	Description of malfunction	Possible remedy
61.0010	Expiratory minute volume is incorrect.	– Replace Spirolog sensor. – Check connection between Spirolog sensor and Control PCB.

Inspiratory flow measurement error group 62

Error code	Description of malfunction	Possible remedy
62.0000	Error in temperature measurement.	– Replace TSI sensor.
62.0001	Error in flow measurement.	– Replace TSI sensor.
62.0002	Incorrect resolution of A/D converter.	– Replace TSI sensor.
62.0003	Wrong TSI sensor type.	– Replace TSI sensor.
62.0004	Incorrect AIR coefficient.	– Replace TSI sensor.
62.0005	Incorrect O2 coefficient.	– Replace TSI sensor.
62.0006	Incorrect checksum.	– Replace TSI sensor.
62.0007	Internal SW error of TSI sensor.	– Replace TSI sensor.
62.0010	EEPROM of TSI sensor is faulty.	– Replace TSI sensor.

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O2 concentration measurement error group 63

Error code	Description of malfunction	Possible remedy
63.0000	O2 sensor no. 2: Sensor not fitted, faulty, or not operational yet.	– Replace O2 sensor no. 2. – Install O2 sensor no. 2. – Allow O2 sensor no. 2 to stabilize.
63.0001	O2 sensor no. 2: Concentration is outside specification.	– Check whether the compressed gas at the O2 connection has a concentration of 100% vol. – Check ambient pressure sensors in Service Mode, test 27. – Calibrate O2 sensor no. 2 to 100 vol.% O2. – Replace O2 sensor no. 2.
63.0004	O2 sensor no. 2: Compensation with default pressure.	– Check ambient pressure sensors in Service Mode, test 27, and adjust if necessary.

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Error code	Description of malfunction	Possible remedy
63.0005	O2 sensor no. 2: Compensation with default temperature.	– Check device temperature in Service Mode, test 16, and expose device to ambient temperature of 5 to 40 °C, if necessary.
63.0010	O2 sensor no. 1: Sensor not fitted, faulty, or not operational yet.	– Replace O2 sensor no. 1. – Install O2 sensor no. 1. – Allow O2 sensor no. 1 to stabilize.
63.0011	O2 sensor no. 1: Concentration is outside specification.	– Check whether the compressed gas at the O_2 connection has a concentration of 100% vol. O2. – Check ambient pressure sensors in Service Mode, test 27. – Calibrate O2 sensor no. 1 to 100 vol.% O2. – Replace O2 sensor no. 1.
63.0012	O2 sensor no. 1: Voltage for temperature measurement is outside of specification (not used for the time being).	–

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Error code	Description of malfunction	Possible remedy
63.0013	O2 sensor no. 1: Temperature measured value is outside of specification (not used for the time being).	–
63.0014	O2 sensor no. 1: Compensation with default pressure.	– Check ambient pressure sensors in Service Mode, test 27, and adjust if necessary.
63.0015	O2 sensor no. 1: Compensation with default temperature.	– Check device temperature in Service Mode, test 16, and expose device to ambient temperature of 5 to 40 °C, if necessary.
63.0020	O2 sensor no. 2: INFO: Sensor not fitted.	– Install sensor.
63.0021	O2 sensor no. 2: INFO: Sensor is faulty.	– Replace sensor.
63.0022	O2 sensor no. 2: INFO: Sensor is not operational yet.	– Allow sensor to warm up.
63.0030	O2 sensor no. 1: INFO: Sensor not fitted.	– Install sensor.
63.0031	O2 sensor no. 1: INFO: Sensor is faulty.	– Replace sensor.

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Error code	Description of malfunction	Possible remedy
63.0032	O2 sensor no. 1: INFO: Sensor is not operational yet.	– Allow sensor to warm up.
63.0080	Temperature measurement for O2: Voltage is outside specification.	– see error code 41.0070. – Replace the O2 Diaphragm PCB.
63.0081	Temperature measurement for O2: Temperature is outside specification.	– see error code 63.0080
63.0090	Measurement difference between the sensors is too high: O2 measurement fault:	– Switch unit off and on again. Calibrate O2 sensors manually. – Replace O2 sensors.
63.0100	Internal error in O2 sensor no. 2 (not used for the time being).	–
63.0101	Internal error in O2 sensor no. 2 (not used for the time being).	–
63.0110	Internal error in O2 sensor no. 1 (not used for the time being).	–
63.0111	Internal error in O2 sensor no. 1 (not used for the time being).	–
63.0120	O2 measurement faulty, detected by SISW.	– see error code 63.0090.

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Error code	Description of malfunction	Possible remedy
63.0130	O2 sensors measure differently, detected by SiSW.	– see error code 63.0090.

Airway temperature measurement error group 64

Error code	Description of malfunction	Possible remedy
64.0000	AWT-01 sensor at Y-piece. Short-circuit in AWT-01 sensor.	– Replace AWT-01 sensor.
64.0001	Inspiratory gas temperature sensor is faulty.	– Replace inspiratory gas temperature sensor (connected to O_2 Diaphragm PCB).

Ambient pressure measurement with S7 error group 65

Error code	Description of malfunction	Possible remedy
65.0000	Offset calibration outside range.	– Carry out Service Mode, test 27. – Replace O_2 Valve PCB.

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Error code	Description of malfunction	Possible remedy
65.0001	Measured value is too high.	– Carry out Service Mode, test 27. – Replace O_2 Valve PCB.
65.0002	Measured value is too low.	– Carry out Service Mode, test 27. – Replace O_2 Valve PCB.
65.0010	Ambient pressure sensor is faulty, detected by SiSW	– Carry out Service Mode, test 27. – Replace O_2 Valve PCB.
65.0011	A/D converter channel for ambient pressure sensor is faulty, detected by SiSW.	– Carry out Service Mode, test 27. – Replace Control PCB.

Ambient pressure measurement with S6 error group 66

Error code	Description of malfunction	Possible remedy
66.0000	Offset calibration outside range.	– Carry out Service Mode, test 27. – Replace O_2 Valve PCB.
66.0001	Measured value is too high.	– Carry out Service Mode, test 27. – Replace O_2 Valve PCB.

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Error code	Description of malfunction	Possible remedy
66.0002	Measured value is too low.	– Carry out Service Mode, test 27. – Replace O_2 Valve PCB.

O2 supply pressure measurement error group 67

Error code	Description of malfunction	Possible remedy
67.0000	Offset calibration outside range.	– Carry out Service Mode, test 27. – Replace O_2 supply pressure sensor.

SiSW MP error group 98

Error code	Description of malfunction	Possible remedy
98.0000	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0010	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0020	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
98.0030	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0040	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0050	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0060	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0070	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0080	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0090	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0095	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0100	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0110	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
98.0115	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0120	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0130	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0140	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0141	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0150	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0160	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0170	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0180	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0190	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
98.0200	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0210	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0220	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0230	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0240	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0250	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0260	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0270	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0280	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0290	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
98.0300	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0310	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0320	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0330	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0340	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0350	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0360	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0370	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0375	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0376	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
98.0380	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0390	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0400	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0410	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0420	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0430	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0440	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0450	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0451	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0460	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
98.0470	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0480	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0490	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0500	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0510	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0520	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0530	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0540	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0550	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0560	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
98.0570	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0580	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0590	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0600	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.0610	Safety software has triggered a device reset.	– Report error to DS Lübeck.
98.10** to 98.14**	Safety software has triggered a device reset.	– Report error to DS Lübeck.

SiSW FP error group 99

Error code	Description of malfunction	Possible remedy
99.0000	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0010	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
99.0020	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0030	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0040	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0050	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0060	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0070	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0080	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0090	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0095	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0100	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
99.0110	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0115	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0120	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0130	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0140	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0141	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0150	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0160	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0170	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0180	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
99.0190	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0200	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0210	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0220	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0230	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0240	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0250	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0260	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0270	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0280	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
99.0290	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0300	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0310	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0320	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0330	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0340	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0350	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0360	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0370	Safety software has triggered a device reset.	– Carry out SW update ≤1.10. – Report error to DS Lübeck.
99.0375	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
99.0376	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0380	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0390	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0400	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0410	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0420	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0430	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0440	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0450	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0451	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
99.0460	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0470	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0480	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0490	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0500	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0510	Safety software has triggered a device reset.	– Report error to DS Lübeck. – Error occurs in SW 1.10. Acknowledge error. The unit can continue with the ventilation. SW 2 will remedy this problem.
99.0520	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0530	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Error code	Description of malfunction	Possible remedy
99.0540	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0550	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0560	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0570	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0580	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0590	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0600	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.0610	Safety software has triggered a device reset.	– Report error to DS Lübeck.
99.10** to 99.14**	Safety software has triggered a device reset.	– Report error to DS Lübeck.

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Alarm Messages

Ventilation monitoring

Upper airway pressure limit

First pressure limit

Cause:

1. The patient fights the ventilator or is coughing.
2. The inspiration tube is kinked or obstructed.
3. One or both pressure sensor(s) deliver(s) too high a measured value.
4. The pressure source delivers a pressure that deviates from the set pressure.

Detection:

1. The measured value of the inspiratory pressure sensor $P_{insp}(t)$ exceeds the value of the upper airway pressure limit Paw-high + offset.

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2. The measured value of the expiratory pressure sensor $P_{exp}(t)$ exceeds the value of the upper airway pressure limit Paw-high.

Suppression:

1. After a cold start and 15 s afterwards (only alarm).

2. During standby and 15 s afterwards (only alarm).

Reaction:

1. Generation of event "Paw stenosis 1" (warning "!!! Airway pressure high").

2. Transmission of event "Paw stenosis 1" to ventilation control to stop inspiration.

Resetting:

1. As soon as next inspiration starts (= start of inspiration flow).

2. Five seconds after occurrence of alarm cause.

3. Value decreases below alarm limit by 5 mbar (ventilation control only).

4. If a measured value becomes invalid, the detected condition will not be restored as a result.

5. Second pressure limit (Paw high + 5 mbar)

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Second pressure limit (Paw high + 5 mbar)

Cause:

1. The patient fights the ventilator or is coughing.
2. The inspiration tube is kinked or obstructed.
3. One or both pressure sensor(s) deliver(s) too high a measured value.
4. Pressure source delivers incorrect pressure.

Detection:

1. The measured value of the inspiratory pressure sensor $P_{insp}(t)$ exceeds the value of the upper airway pressure limit Paw-high + offset for more than 200 ms.
2. The measured value of the expiratory pressure sensor $P_{exp}(t)$ exceeds the value of the upper airway pressure limit Paw-high for more than 200 ms.
3. The measured value of the inspiratory pressure sensor $P_{insp}(t)$ exceeds the value of the upper airway pressure limit Paw-high + offset(t) +5 mbar for more than 50 ms.
4. The measured value of the expiratory pressure sensor $P_{exp}(t)$ exceeds the value of the upper airway pressure limit Paw-high +5 mbar for more than 50 ms.

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5. The input value "Paw (SiSW)" shows an error.

Suppression:

1. After a cold start and 15 s afterwards (only alarm).

2. During standby and 15 s afterwards (only alarm).

Reaction:

1. Generation of event "Paw stenosis 2" (warning "!!! Airway pressure high").

2. Transmission of event "Paw stenosis 2" to ventilation control in order to relieve the lungs or to open the electrical safety valve.

3. Detection 5: Alarm only.

Resetting:

1. When airway pressure reaches 5 mbar (relief successful), but at the earliest after 500 ms.

2. Five seconds after occurrence of event cause.

3. Detection 5: The input value "Paw (SiSW)" does no longer show an error.

4. If a measured value becomes invalid, the detected condition will not be restored as a result.

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Lower airway pressure limit

Cause:

1. The hose system or one of the hoses is disconnected or leaky.

2. The measured value delivered by the expiratory pressure sensor is too low.

Detection:

1. In all ventilation modes with a $PEEP_{setting}$ of at least 3 mbar:
   If the airway pressure $P_{exp}(t)$ measured with the expiratory pressure sensor is below the set PEEP, then the difference between the $PEEP_{setting}$ and $P_{exp}(t)$ is integrated in a summation memory (limited to 4.5 mbar).
   An alarm is given when the value in the summation memory exceeds 22.5 mbar*s. The summation memory is deleted if the measured airway pressure exceeds the $PEEP_{setting}$ again. The summation memory is also deleted after changing the operating mode or setting the PEEP below 3 mbar.

2. In volume-controlled ventilation (IPPV, SIMV, apnea ventilation) or pressure-controlled ventilation (BIPAP, AutoFlow modes):
   In two subsequent mandatory inspiratory breaths (machine inspiration) the measured value Pexp(t) does not reach the limit value Pmin for more than the minimum time Tmin in each case.
   The level and derivation of the Pmin threshold depend on the ventilation mode:

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volume controlled: Pmin = PEEPsetting +5 mbar
pressure-controlled: Pmin = 0.5 * (PEEPsetting +Pinsp)
The minimum time is determined by:
Tmin = min (¼ * Tinsp, measured, 100 ms)
Tinsp, measured, is derived from the phase information of the ventilation control.

Suppression:

1. Detection 1 is activated only at $PEEP_{setting}$ ≥3 mbar.

2. After cold start and 15 s afterwards.

3. During standby and 15 s afterwards.

4. During a detected disconnection and 15 s afterwards.

Reaction:

1. Generation of event "Airway pressure low" (warning "!!! Airway pressure low"). The warning is delayed in relation to the event by the adjustable time Tdisconnect.

Resetting:

1. Detection 1: If the summation memory has been deleted.

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2. Detection 2: During the next inspiratory breath, the measured value $P_{exp}(t)$ reaches the limit value P_{min} for more than T_{min}.

3. Detection 2: After switching to pure spontaneous breathing mode.

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Minute volume

MV low

Cause:

1. Spontaneous ventilation of the patient is insufficient.
2. Spontaneous ventilation of the patient is sufficient, but the expiratory flow measured is too low due to leakages in the expiratory tube.
3. The flow control unit is faulty and therefore delivers too low an inspiratory flow.
4. The flow sensor is faulty and therefore measured values delivered are too low.

Detection:

1. The measured value MV(t) is below the lower MV limit value MV low.

Suppression:

1. After a cold start and 2 minutes afterwards.
2. During standby and 2 minutes afterwards.
3. When flow monitoring is off and 2 minutes afterwards.

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4. During detected disconnection and 2 minutes afterwards.

5. The alarm can be activated by the user under mask ventilation (NIV).

Reaction:

1. Generation of event "MV low" (warning "!!! MV low").

Resetting:

1. The measured value MV(t) exceeds the limit value MV low.

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MV high

Cause:

1. Spontaneous ventilation of the patient is too high.
2. The flow control unit is faulty and therefore delivers too high an inspiratory flow.
3. The flow sensor is faulty and therefore measured values delivered are too high.

Detection:

1. The measured value MV(t) exceeds the limit value MV high set by the user.

Suppression:

1. After a cold start and 15 s afterwards.
2. During standby and 15 s afterwards.
3. When flow monitoring is off.

Reaction:

1. Generation of event "MV high" (warning "!!! MV high").

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Resetting:

1. The measured value MV(t) is below the limit value MV high.

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Inspiratory tidal volume

VTi low

Cause:

1. The setting "FlowAcc" is too low.
2. The setting "Tinsp" is too low.
3. The setting "Pinsp" or "Pmax" is too low.

Detection:

1. The input value "VTi low" displays too low a tidal volume.

Suppression:

1. After a cold start and 15 s afterwards.
2. During standby and 15 s afterwards.
3. During a detected disconnection and 15 s afterwards.

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Reaction:

1. The event "VTi low (1)" (advisory "! Tidal volume low") is generated after the second occurrence of the event "VTi low".

2. The event "VTi low (2)" (caution "!! Tidal volume low") is generated after the fourth occurrence of the event "VTi low".

Resetting:

1. The caution message "!! Tidal volume low" was acknowledged with the "Alarm reset" key. Only the caution message (event "VTi low (2)") is reset, not the advisory message.

2. The input value "VTi low" does no longer display too low a tidal volume.

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VTi high

Cause:

1. Too high a tidal volume is applied due to a change in the state of the lungs.

2. Spontaneous ventilation of the patient is too high.

Detection:

1. During a mandatory inspiration (volume-controlled, pressure-controlled) the measured value VTi(t) exceeds the limit value VTi high set by the user.

2. During a spontaneous inspiration (pressure-assisted, spontaneous) the measured value VTi(t) exceeds the limit value VTi high set by the user.

Suppression:

1. After a cold start and 15 s afterwards (only alarm).

2. During standby and 15 s afterwards (only alarm).

3. During a detected disconnection and 15 s afterwards (only alarm).

4. The alarm can be activated by the user under mask ventilation (NIV).

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Reaction:

1. After the first breath: Generation of the event "VTi high (1)" (advisory "! Tidal volume high").

2. After the third breath: Generation of the event "VTi high (2)" (warning "!!! Tidal volume high").

3. Transmission of event to ventilation control to stop inspiration.

There are counters for detection 1 and 2 which lead to reaction 1 or 2.

Resetting:

1. Detection 1: At the end of a mandatory inspiration, the applied tidal volume is below the set monitoring limit again.

2. Detection 1: After switching to pure spontaneous breathing mode.

3. Detection 2: At the end of a spontaneous inspiration, the applied tidal volume is below the set monitoring limit again.

4. Detection 2: There was no spontaneous inspiration between two mandatory inspirations.

5. Detection 2: After switching to pure mandatory mode.

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Oxygen concentration

FiO2 low

Cause:

1. The oxygen control cannot reach the correct FiO2 set.

Detection:

1. The measured value FiO2(t) is below the limit value FiO2 low.
   This error detection is provided with an error counter.

Suppression:

1. After a cold start and 2 minutes afterwards.
2. During standby and 2 minutes afterwards.
3. When O2 monitoring is off and 2 minutes afterwards.
4. During calibration of the O2 sensor and 2 minutes afterwards.
5. After adjusting the $FIO2_{target\ value}$ and 2 minutes afterwards.

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Reaction:

1. Generation of event "FiO2 low" (warning "!!! FiO2 low").

Resetting:

1. The error counter is below the limit value of the alarm.

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FiO2 high

Cause:

1. The oxygen control cannot reach the correct FiO2 set.

Detection:

1. The measured value FiO2(t) exceeds the limit value FiO2 high. This error detection is provided with an error counter.

Suppression:

1. After a cold start and 2 minutes afterwards.
2. During standby and 2 minutes afterwards.
3. When O2 monitoring is off and 2 minutes afterwards.
4. During calibration of the O2 sensor and 2 minutes afterwards.
5. After adjusting the $FIO2_{target\ value}$ and 2 minutes afterwards.

Reaction:

1. Generation of event "FiO2 high" (warning "!!! FiO2 high").

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Resetting:

1. The error counter is below the limit value of the alarm.

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FiO2 limit values

As described in chapters FiO2 low and FiO2 high, the measured value FiO2(t) is compared to an upper and a lower limit value. An alarm is generated if there is a deviation. These two limit values are generated as follows:

Normal operation (concentrator is not active)

– FiO2 low = FiO2 target value -8 vol.%

– FiO2 high = FiO2 target value +8 vol.%

– Fixed alarm limit = FiO2 low ≥18 vol.%

Concentrator is active

– The FiO2 alarm limits set by the user are used.

Remark: Bronchial suction (oxygenation) changes the set FiO2 concentration to 100%. The limit value is changed at the same time.

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Change in breathing cycle

Apnea

Cause:

1. Spontaneous breathing of patient has stopped.
2. Hose system is disconnected or there is a major leakage.
3. The flow sensor is defective.

Detection:

1. If, in all operating modes, the "ExpFlow start" and "ExpFlow end" information is missing for more than the set apnea alarm time, this will be regarded as apnea.
2. If, in spontaneous and mixed operating modes, the "ExpFlow start" and "ExpFlow end" information is missing for more than the set apnea alarm time, this will be regarded as apnea.
3. The input value "Apnea (SiSW)" shows an apnea condition.

Suppression:

1. After a cold start and 15 s afterwards.

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2. During standby and 15 s afterwards.

3. During a detected disconnection and for the period T_{apnea} afterwards.

4. A "Fail to Cycle" alarm has occurred.

5. An "Airway pressure high" alarm has occurred.

6. An "Airway pressure low" alarm has occurred.

7. Hold condition is active (with insp. hold).

8. Flow monitoring is switched off.

9. The alarm can be activated by the user under mask ventilation (NIV).

When flow monitoring is switched off, only that part of the monitoring is suppressed which detects the error by using the expiration start and expiration end information from the expiratory flow sensor.

Reaction:

1. Generation of the event "Apnea" (warning "!!! Apnea")

2. Transmission of the event "Apnea" to the ventilation control to switch on apnea ventilation, if applicable.

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Resetting:

1. Detection 1 and 2: At least one part of the information about inspiration (that is, start or end) and one part of the information about expiration are no longer missing.

2. The input value "Apnea (SiSW)" no longer shows an apnea condition.

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Fail to Cycle

Cause:

1. The ventilator does no longer generate control information of the flow-control unit.
2. Due to device settings, only very low volumes can be applied if the patient’s lungs are hard.

Detection:

1. If, in pure controlled modes (IPPV, SIMV), the "ExpFlow start" and "ExpFlow end" information is missing for more than the set apnea alarm time, this will be regarded as "Fail to Cycle".

Suppression:

1. After a cold start and 15 s afterwards.
2. During standby and 15 s afterwards.
3. During a detected disconnection and for the period T_{apnea} afterwards.
4. An "Airway pressure high" alarm has occurred.
5. An "Airway pressure low" alarm has occurred.
6. Hold condition is active (with insp. hold).

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Reaction:

1. Generation of the event "Fail to Cycle" (warning "!!! Fail to Cycle").

Resetting:

1. At least one part of the inspiration start or inspiration end information is no longer missing.

Note: The alarms "Apnea" and "Fail to Cycle" are mutually exclusive because they are only mode-dependent variations.

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Apnea ventilation

Cause:

1. Apnea ventilation was switched on due to a detected apnea.

Detection:

1. The input value shows an apnea ventilation.

Suppression:

1. None.

Reaction:

1. Generation of the event "Apnea vent" (caution "!! Apnea ventilation").

Resetting:

1. The alarm was confirmed with the "Alarm Reset" key.
2. Switchover to another operating mode; this also acknowledges the alarm.

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High respiratory frequency

Cause:

1. Rapid breathing (tachypnea).

Detection:

1. The measured value $f_{tot}(t)$ exceeds the limit value f high

Suppression:

1. After a cold start and 15 s afterwards.
2. During standby and 15 s afterwards.

Reaction:

1. Generation of event "High frequency" (warning "!!! High frequency").

Resetting:

1. The error counter is below the limit value of the alarm.

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ASB >4 seconds

Cause:

1. Leakage in hose system.
2. Expiratory valve is leaky.
3. Pressure sensor is faulty.

Detection:

1. The ASB breath is carried out and monitored by the ventilation control.

Suppression:

1. After a cold start and 15 s afterwards.
2. During standby and 15 s afterwards.

Reaction:

1. When the ASB cycle is interrupted for the first time, the event "First ASB interruption" is generated (advisory "! ASB > 4 s").

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2. After the third interruption of the ASB cycle in sequence, the event "Third ASB interruption" is generated (warning "!!! ASB > 4 s").

Resetting:

1. The ventilation control completes the ASB cycle within 4 s.

2. After switching to an operating mode without ASB.

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Inspiratory airway temperature

Cause:

1. The humidifier heats up the inspiratory gas to an excessively high level.
2. The measured value delivered by breathing gas temperature sensor is too high.

Detection:

1. One of the input values shows too high a temperature.

Suppression:

1. After cold start and 15 s afterwards.
2. During standby and 15 s afterwards.

Reaction:

1. Generation of event "Temp. AWT01 high" (warning "!!! Breathing gas temp. high").
2. Generation of event "Temp. SiSW high" (warning "!!! Temperature high").

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Resetting:

1. None of the input values shows an error.

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User functions

Standby activation

Cause:

1. Standby was activated by the user.

Detection:

1. Standby has been activated.

Suppression:

1. None.

Reaction:

1. Generation of event "Standby activated" (warning "!!! Standby activated").

Resetting:

1. The alarm was confirmed with the "Alarm Reset" key.
2. Standby is deactivated.

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Flow monitoring

Cause:

1. Flow monitoring has been switched off by the user.

Detection:

1. Flow monitoring has been switched off by the user.

Suppression:

1. None.

Reaction:

1. Generation of event "No flow monitoring" (advisory "! Flow monitoring off").

Resetting:

1. Flow monitoring is switched on again.

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O2 monitoring

Cause:

1. O2 monitoring has been switched off by the user.

Detection:

1. O2 monitoring has been switched off by the user.
2. O2 monitoring was already switched off before the cold start was carried out.

Suppression:

1. None.

Reaction:

1. Detection 1: Generation of the event "No O2 monitoring" (advisory "! O2 monitoring off").
2. Detection 2: Generation of the event "No O2 monitoring" (caution "!! O2 monitoring off").

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Resetting:

1. Detection 1: O2 monitoring is switched on again.

2. Detection 2: The alarm was confirmed with the "Alarm Reset" key.

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Mask ventilation (NIV)

Cause:

1. Alarm was deactivated by the user.

Detection:

1. Alarms have been deactivated.

Suppression:

1. None.

Reaction:

1. Generation of event "Apnea alarm off" (advisory "! Apnea alarm off").
2. Generation of event "MV low alarm off" (advisory "! MV low alarm off").
3. Generation of event "VT1 high alarm off" (advisory "! VTi high alarm off").

Resetting:

1. Alarm was reactivated by the user.

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Nebulization

Cause:

1. The user has activated the nebulizer.

Detection:

1. The input value shows an active nebulizer.

Suppression:

1. None.

Reaction:

1. Generation of event "Nebulizer active" (advisory "! Nebulizer on").

Resetting:

1. The input value shows that the nebulizer is no longer active.

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Inspiration hold

Cause:

1. The user has pressed the "Insp. hold" key for more than 15 s.

Detection:

1. The input value shows an interruption.

Suppression:

1. None.

Reaction:

1. Generation of event "Insp. hold interruption" (advisory "! Insp. hold interrupted").

Resetting:

1. The input values shows that the user has released the key.

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Monitoring of sensors

Airway pressure sensors

Cause:

1. A pressure sensor is faulty, e.g. diaphragm is damaged.
2. Offset voltage of one sensor or both sensors has drifted too much.
3. The sensors are no longer supplied with voltage.
4. The calibration valve of one sensor is faulty and, as a result, the sensor is permanently switched to atmospheric pressure.
5. A pressure sensor delivers incorrect, but dynamic measured values.

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Detection:

1. The maximum and minimum values of a pressure sensor are measured during the course of a breathing cycle (patient cycle). At the end of the breathing cycle (inspiration flow start) the difference between maximum and minimum values is less than 0.3 mbar. The breathing cycle is derived from the breathing phase information "start of inspiration" which again is only accepted if a start of an expiration has been detected since the most recent start of an inspiration.
   PT1-filtered measured values (t = 100 ms) are used (PT1 = type of filter). This error detection is provided with an error counter.

2. The measured values of the two pressure sensors differ by more than 5 mbar.

3. The offset of one pressure sensor has drifted between two calibrations.

4. The offset of one pressure sensor is no longer in the permissible range after a calibration.

5. The measured value of one pressure sensor is outside the permissible range.

6. One of the input values "P_{insp} sensor (SiSW) malfunction" or "P_{exp} sensor (SiSW) malfunction" shows an error.

Suppression:

1. None.

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Reaction:

1. Generation of event "Pressure measurement malfunction" (warning "!!! Pressure meas. inop.").

2. Detection 1 and 2: Message of monitoring events (Paw sensor malfunction) to calibration and measured-value detection of Paw sensors.

Resetting:

1. Detection 1: The error counter is below the limit value of the alarm.

2. Offset has not drifted between two calibrations.

3. Offset is within permissible range again.

4. The measured value is within permissible range again.

5. The input values of the SiSW no longer show an error.

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Expiratory flow sensor

Expiratory flow sensor faulty

Cause:

1. Flow sensor is faulty.
2. The expiratory valve is faulty, there was a flow at the sensor during calibration.
3. Flow sensor disconnected.

Detection:

1. Measuring wire or compensation wire broken.
2. Calibration is outside the permissible range.
3. The flow sensor measured value is greater than 100 L/min for more than 15 s.
4. The input value "$Flow_{exp}$ malfunction (SiSW)" shows an error.

Suppression:

1. Flow monitoring is switched off.

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Reaction:

1. Generation of event "Flow measurement malfunction" (warning "!!! Flow measurement inop").

Resetting:

1. None of the above mentioned detection criteria shows an error condition.

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Expiratory flow sensor not positioned correctly

Cause:

1. Flow sensor not inserted in patient system (flow sensor switch open).

Detection:

1. The flow sensor switch is detected "open".

Suppression:

1. Flow monitoring is switched off.

Reaction:

1. Generation of event "Flow measurement malfunction" (warning "!!! Flow sensor?").

Resetting:

1. The error counter is below the limit value of the alarm.

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Inspiratory flow sensor

Cause:

1. Total failure.
2. Measurement failed.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Flow measurement malfunction" (warning "!!! Device failure XX.YYYY").

Resetting:

1. No errors present.

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Oxygen sensors

Cause:

1. Total failure.
2. Measurement failed.

Detection:

1. One of the input values shows an error.

Suppression:

1. After cold start and 15 s afterwards.
2. During standby and 15 s afterwards.
3. O2 monitoring is switched off.

Reaction:

1. Generation of event "O2 measurement malfunction" (warning "!!! O2 measurement inop").

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Resetting:

1. None of the input values shows an error.

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Breathing-gas temperature sensor at Y-piece

Breathing-gas temperature sensor faulty

Cause:

1. The measured value of the breathing-gas temperature sensor is that low that a short-circuit in the sensor or in the sensor cable is likely.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Temperature measurement malfunction" (warning "!!! Temperature meas. inop.").

Resetting:

1. None of the input values shows an error.

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Breathing-gas temperature sensor disconnected

Cause:

1. The measured value of the breathing-gas temperature sensor is that high that a sensor cable rupture or a disconnected sensor is likely.

Detection:

1. The input value shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Temperature sensor?" (warning "!!! Temperature sensor?").

Resetting:

1. The input value no longer shows an error.

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Ambient pressure sensors

Cause:

1. Converter faulty (measured value outside permissible range).
2. Sensor is faulty.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Ambient pressure measurement malfunction" (warning "!!! Ambient press. meas. inop").

Resetting:

1. None of the input values shows an error.

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Device internal temperature sensors

Cause:

1. The measured value of the breathing-gas temperature sensor is that low that a short-circuit in the sensor is likely.

2. The measured value of the breathing-gas temperature sensor is that high that an open circuit at the sensor is likely.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Temperature sensor malfunction" (warning "!!! Device failure XX.YYYY").

Resetting:

1. None of the input values shows an error.

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Monitoring of actuators

Expiratory valve

Cause:

1. Expiratory valve faulty.

2. Expiratory valve builds up insufficient closing pressure or no closing pressure at all.

Detection:

1. An expiration flow was measured in more than 3 mandatory breaths during inspiration and in each inspiration the integral of this expiration flow exceeded the value of the inspiratory tidal volume by 25%.
   The inspiratory tidal volume was at least 12.5 mL in each case.

Suppression:

1. None.

Reaction:

1. Generation of event "Exp. valve malfunction" (warning "!!! Exp. valve inop.").

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Resetting:

1. The first mandatory inspiration, in which the leakage through the expiratory valve is less than 25% of the inspiratory tidal volume, resets the alarm.

1. After switching to non-mandatory ventilation.

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Monitoring of PEEP

Cause:

1. Expiratory valve faulty.

Detection:

1. The measured end-expiratory pressure PEEP(t) differs from the $PEEP_{target\ value}$ by more than -5 mbar (PEEP(t) < $PEEP_{target\ value}$ -5 mbar).

2. The measured end-expiratory pressure PEEP(t) differs from the $PEEP_{target\ value}$ by more than +5 mbar (PEEP(t) > $PEEP_{target\ value}$ +5 mbar) and there was no "air trapping" during PEEP measurement.

Suppression:

1. After a cold start and 15 s afterwards.

2. During standby and 15 s afterwards.

Reaction:

1. Generation of event "PEEP malfunction" (warning "!!! PEEP inop.").

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Resetting:

1. The measured PEEP(t) is in the range $PEEP_{setting}$ ±5 mbar.

2. After switchover to another operating mode.

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Expiratory resistance (PEEP high)

Cause:

1. Bacterial filter clogged.

2. Expiratory tube partly kinked.

3. Expiratory valve faulty.

Detection:

1. The following is checked at the end of each mandatory expiration:
   - The airway pressure Paw(t) must be below P_G for at least 150 ms in sequence.
   - Or the airway pressure at the end of the expiration must be below P_G and the expiration time must not exceed 500 ms.
   If neither condition is met, the counter is incremented.
   The expiratory time is the shortest time between the start of a mandatory expiration or the end of the last patient inspiration and the end of the mandatory expiration.

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2. If, during the mandatory expiration phase, the airway pressure Paw(t) does not decrease below the limit value P_G, a time counter measures the duration of this condition. An error is reported when the time counter reaches the value 15 s. The time counter is stopped during a mandatory inspiration. The time counter is reset immediately when the airway pressure falls below the limit value P_G.
   The limit value P_G is: P_G = PEEPsetting +8 mbar.

Suppression:

1. After a cold start and 15 s afterwards (only alarm).

2. During standby and 15 s afterwards (only alarm).

Reaction:

1. Generation of event "PEEP high" (alarm generating system generates an alarm for at least 15 s ±2 s including the warning "!!! PEEP high").

2. Transmission of event "Paw stenosis 2" to ventilation control in order to relieve the lungs or to open the electrical safety valve.

Resetting:

1. Detection 1: The error counter is below the limit value of the alarm.

2. Detection 1: After switching to a pure spontaneous breathing mode.

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3. The pressure has been relieved for at least 1 s and the measured airway pressure Paw(t) is below the described limit value.

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Gas supplies

Air intake

Cause:

1. Air intake filter is missing.
2. Air intake filter is dirty.
3. Air intake opening of air intake filter is obstructed.

Detection:

1. The micro-switch (located on the filter mount) is set to position "filter missing".
2. The input value "Microfilter blocked (SiSW)" shows an error.

Suppression:

1. None.

Reaction:

1. Detection 1: Generation of the event "Microfilter missing" (warning "!!! Microfilter missing").

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2. Detection 2: Generation of the event "Intake channel obstructed" (warning "!!! Microfilter blocked").

Resetting:

1. Detection 1: The micro-switch is set to position "filter present".

2. Detection 2: The input value no longer shows an error.

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Blower

Cause:

1. Blower blocked.
2. Blower runs at maximum speed.
3. Bypass valve is jammed.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Blower malfunction" (warning "!!! Device failure XX.YYYY").

Resetting:

1. None of the input values shows an error.

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Speed adaptation

Cause:

1. Leakage in the blower or deviation from the blower characteristic.
2. Limitation of speed due to high inspiratory breathing gas temperature.

Detection:

1. The input value "Minor blower deficiency" shows an error.
2. The input value "Major blower deficiency" shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Minor blower deficiency" (no alarm, only a log entry).
2. Generation of event "Major blower deficiency" (advisory "! Temperature high").

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Resetting:

1. The input value "Major blower deficiency" no longer shows an error.

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No oxygen

Cause:

1. Oxygen supply not connected or damaged.
2. O2 supply sensor faulty.

Detection:

1. The input value "O2 supply critical" show too low a supply pressure.
2. The input value "O2 supply low" show too low a supply pressure.

Suppression:

1. The device is in concentrator mode.

Reaction:

1. Generation of event "No O2" (warning "!!! O2 supply down").
2. Message of event "No O2" to routine functions.

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Resetting:

1. The input value "O2 supply critical" does no longer show an error.
2. The input value "O2 supply low" does no longer show an error.

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Oxygen supply high

Cause:

1. Oxygen supply pressure is too high.
2. O2 supply sensor faulty.

Detection:

1. The input value "O2 supply pressure high" show too high a supply pressure.

Suppression:

1. None.

Reaction:

1. Generation of event "O2 supply pressure high" (caution "!! O2 supply pressure high").
2. Message of event "No O2" to routine functions "bronchial suction" and "nebulizer".

Resetting:

1. The input value "O2 supply pressure high" does no longer show an error.

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Monitoring of central system

Boot procedure

Testing of watchdogs

Cause:

1. Watchdog master processor (MP) does not trigger a reset.
2. Watchdog front processor (FP) does not trigger a reset.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Watchdog faulty" (warning "!!! Device failure XX.YYYY").

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Resetting:

1. None.

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5-V voltage monitoring test

Cause:

1. 5-V voltage monitoring faulty.
2. Reset controller faulty.
3. Test device of voltage monitoring faulty.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "5 V high. Monitoring faulty" or "5 V low monitoring faulty" (warning "!!! Device failure XX.YYYY").

Resetting:

1. The input value no longer shows an error.

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System relief

Cause:

1. Hardware error.

Detection:

1. The input value shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "System relief faulty" (warning "!!! Device failure XX.YYYY").

Resetting:

1. None.

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Timer

Cause:

1. Timer faulty.

Detection:

1. The input value shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Time basis faulty" (warning "!!! Device failure XX.YYYY").

Resetting:

1. The input value no longer shows an error.

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Settings

Cause:

1. Memory error.

Detection:

1. The input value shows inconsistent settings.

Suppression:

1. None.

Reaction:

1. Generation of event "Check settings" (caution "!! Check settings").

Resetting:

1. The alarm was confirmed with the "Alarm Reset" key.

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Boot sequence

Cause:

1. Memory error.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Error in boot sequence" (warning "!!! Device failure XX.YYYY").

Resetting:

1. None.

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Memory

RTC battery

Cause:

1. The battery of the RTC is flat.

Detection:

1. The input value shows a flat RTC battery.

Suppression:

1. None.

Reaction:

1. Generation of event "Battery flat" (warning "!!! Device failure XX.YYYY").

Resetting:

1. None.

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Data retention in EEPROM and RTC RAM

Cause:

1. EPROM is faulty.
2. RTC is faulty.
3. Data contents destroyed due to a reset while writing to EEPROM.

Detection:

1. Data retention reports an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Data loss" (warning "!!! Device failure XX.YYYY").

Resetting:

1. None.

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RAM

Cause:

1. RAM faulty.

Detection:

1. The entire RAM of the device has to be checked.

Suppression:

1. None.

Reaction:

1. Generation of event "RAM faulty" (warning "!!! Device failure XX.YYYY").

Resetting:

1. None.

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ROM

Cause:

1. ROM faulty.

Detection:

1. A complete ROM test is carried out during the self-test.
2. A ROM test is also carried out cyclically in normal operating mode during which the ROM areas to be tested per program cycle have to be adapted to the run-times.

Suppression:

1. None.

Reaction:

1. Generation of event "ROM faulty during self-test" or "ROM faulty during cyclic test" (warning "!!! Device failure XX.YYYY").
2. Triggering of a reset which returns the device to cold start if the error has been detected during the self-test. "Only" an alarm is generated during cycling testing.

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Resetting:

1. None.

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Operating voltages

Cause:

1. Voltage supply is faulty.

2. A/D converter faulty.

Detection:

1. The operating voltages are cyclically compared to defined tolerance limits (see Table). This error detection is provided with an error counter per voltage to be monitored.

Supply voltages	Tolerance
+15 V	±20%
-15 V	±20%
+24 V	±20%
+5 V reference voltage	±4%

2. The input value "Voltage faulty (SiSW)" reports an error.

Suppression:

1. None.

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Reaction:

1. Generation of event "Voltage faulty" (warning "!!! Device failure XX.YYYY").

Resetting:

1. Operating voltages are within tolerance limits again.
2. The input value "Voltage faulty (SiSW)" no longer reports an error.

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Power pack

Charge state of internal battery

Cause:

1. Battery capacity is only sufficient for residual operating time.
2. Battery capacity down or shutdown is likely to happen any moment.

Detection:

1. Charge state is below the 30% threshold.
2. Charge state is below the 3% threshold.

Suppression:

1. If the internal battery is out of service and 20 s afterwards, both events will be issued as advisory messages.

Reaction:

1. Detection 1: Generation of event "Int. battery low" (caution !! Int. battery low").

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2. Detection 2: Generation of event "Int. battery flat" (warning !!! Int. battery almost discharged").

Resetting:

1. Detection 1: Charge state reaches at least the 35% threshold.

2. Detection 2: Charge state reaches at least the 30% threshold.

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Status of internal battery

Cause:

1. Internal battery not connected.
2. Internal battery faulty.
3. Internal battery is not charged.

Detection:

1. The input value "Int. battery present" shows that battery is missing.
2. Although no battery is present, the charging procedure is carried out or a sufficient battery charge (>90%) is reported.
3. Although the internal battery and the external AC supply are present, the charging procedure is not carried out when the battery charge is low (<90%).

Suppression:

1. None.

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Reaction:

1. Detection 1: Generation of event "No battery" (warning "!!! No int. battery").
2. Detection 2: Generation of event "Int. battery faulty" (warning "!!! Int. battery failed").
3. Detection 3: Generation of event "No battery charging" (warning "!!! No battery charging").

Resetting:

1. Detection 1: The input value "No int. battery" no longer reports a missing battery.
2. Detection 2: Error condition is no longer present.
3. Detection 3: Error condition is no longer present.

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Power failure

Cause:

1. Failure of external AC power.
2. Failure of external AC and external DC voltages.

Detection:

1. The input value "External AC" shows a failure of the voltage source and "External DC" is present.
2. Both input values "External DC" and "External AC " show a failure of the voltage sources.

Suppression:

1. None.

Reaction:

1. Detection 1: Generation of event "Ext. DC active" (advisory "! Ext. DC active").
2. Detection 2: Generation of event "Int. battery activated" (caution "!! Int. battery activated").

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Resetting:

1. Detection 1: The voltage "External AC" is present again.
2. Detection 2: Both voltage sources are present again.

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Main switch

Cause:

1. The user has operated the main switch too many times.
2. Hardware error (bouncing, short-circuit, open-circuit).

Detection:

1. The input value "Main switch overused (SiSW)" shows an error.
2. The input value "Main switch failed (SiSW)" shows an error.

Suppression:

1. None.

Reaction:

1. Detection 1: Generation of event "Main switch overused" (caution "!! Main switch overused").
2. Detection 2: Generation of event "Main switch failed" (warning "!!! Device failure XX.YYYY").

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Resetting:

1. Detection 1: The alarm was confirmed with the "Alarm Reset" key.
2. Detection 2: None.

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Ambient pressure

Cause:

1. Atmospheric pressure too high.
2. Atmospheric pressure too low.
3. One of the sensors is faulty.

Detection:

1. One of the input values shows too high an atmospheric pressure (P(t) >1200 mbar).
2. One of the input values shows too low an atmospheric pressure (P(t) <600 mbar).

Suppression:

1. After a cold start and 15 s afterwards.
2. During standby and 15 s afterwards.

Reaction:

1. Detection 1: Generation of the event "Microfilter missing" (warning "!!! Microfilter missing").

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2. Detection 2: Generation of the event "Atmospheric pressure low" (advisory "! Atmospheric pressure low").

Resetting:

1. Detection 1: None of the input values shows an error (P(t) <1200 mbar).

2. Detection 2: None of the input values shows an error (P(t) >600 mbar).

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Device internal temperature

Cause:

1. Ambient temperature is too high.
2. Fan is faulty.

Detection:

1. The input value shows too high a temperature (>60 °C).

Suppression:

1. None.

Reaction:

1. Generation of event "Int. temp. high" (caution !! Int. temperature high").

Resetting:

1. The input value no longer shows an error (temperature is >60<°C).

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Device fan

Cause:

1. Device fan is faulty.
2. Measurement electronics are faulty.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Fan malfunction" (warning "!!! Malfunction fan"). If the input value "Measurement electronics faulty (SiSW)" shows an error, the warning "!!! Device failure XX.YYYY" will be generated.

Resetting:

1. None of the input values shows an error.

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Keypad

Cause:

1. The user has pressed the key too many times.
2. The user keeps the key pressed all the time.
3. Hardware error (bouncing, short-circuit, open-circuit).

Detection:

1. The input value "Key XX overused" shows an error.
2. The input value "Key XX failed" shows an error.

Suppression:

1. None.

Reaction:

1. Detection 1: Generation of event "Key XX overused" (caution "!! Key XX overused").
2. Detection 2: Generation of event "Key XX failed" (caution "!! Key XX failed").

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Resetting:

1. Detection 1: The alarm was confirmed with the "Alarm Reset" key.
2. Detection 2: The input value no longer shows an error (user has released the key).

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Loudspeaker

Cause:

1. Loudspeaker faulty.
2. Ventilation SW has not triggered an alarm requested by the SiSW.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

Reaction:

1. Generation of event "Loudspeaker faulty" (warning "!!! Device failure XX.YYYY").

Resetting:

1. None.

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Auxiliary alarm

Cause:

1. The GoldCap capacity is too low.
2. The GoldCap test device is faulty.
3. The GoldCap supply voltage is too high.
4. The GoldCap supply voltage is too low.
5. The GoldCap resistance is too high.
6. The auxiliary alarm test current is too high.
7. The auxiliary alarm test current is too low.

Detection:

1. One of the input values shows an error.

Suppression:

1. None.

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Reaction:

1. Generation of event "Auxiliary alarm faulty" (warning "!!! Device failure XX.YYYY").

Resetting:

1. None of the input values shows an error.

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Device reset

Cause:

1. The ventilation SW has detected an error that cannot be corrected.
2. The SiSW has detected an error that can only be corrected by restarting the device.

Detection:

1. The input value shows an error.

Suppression:

1. None

Reaction:

1. Generation of event "SW error" (warning "!!! Device failure XX.YYYY").

Resetting:

1. The alarm was confirmed with the "Alarm Reset" key.

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Repair Information/Error Events

Known errors

Error	Possible cause/remedy
The alarm message "No int. battery" is displayed.	Refer to flow chart "Warning message "!!! No int. battery"".
Unit cannot be switched off.	Refer to "Unit cannot be switched off".
Options are lost when updating software from SW 1.00 to SW 1.10.	Refer to "Error when updating from SW 1.00 to 1.10".
Options are lost when updating software from SW 1.01 to SW 1.10.	Refer to "SW 1.01 to 1.10 update procedure".
When Savina is in the device mount the cover of the O2 sensors cannot be removed.	Refer to "Reworking the cover of the O2 sensors".

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Error	Possible cause/remedy
Discharging of internal battery	If the unit is not used for a prolonged period of time (storage, etc.) the internal battery may discharge. The message "Warning message "!!! No int. battery"" appears upon power-on. Therefore, it is necessary to remove the fuse of the internal battery in such predictable situations. See also "Instructions for Use/Operating Instructions" under "Preparation".
O2 sensors cannot be calibrated.	Refer to "Possible errors during O2 calibration".

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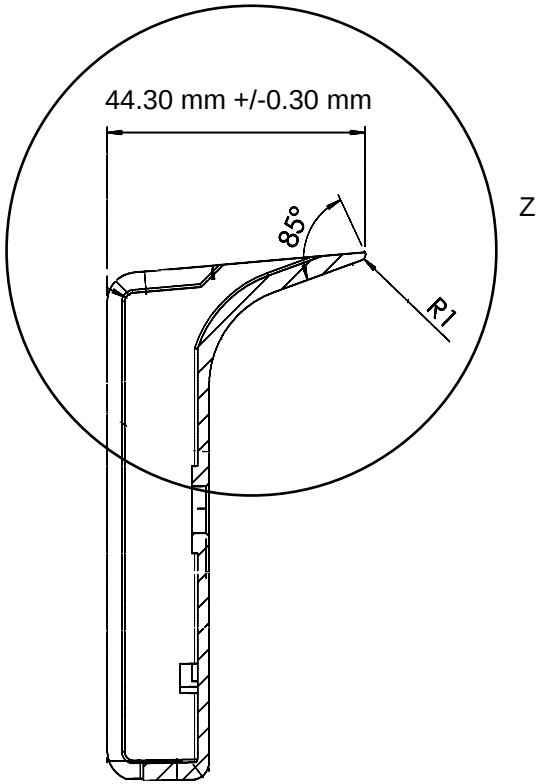
Reworking the cover of the O2 sensors

In the first batch of units it may happen that the cover of the O2 sensor cannot be removed when the unit is located in the device mount. In this case, it is possible to mechanically rework the cover (see "Fig.1:").

Old:



New:

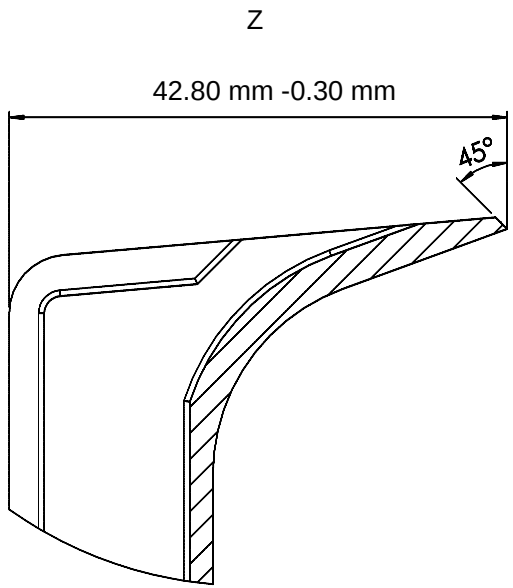


Fig.1: Reworking the cover of the O2 sensors

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Warning message "!!! No int. battery"

This alarm message is generated if battery voltage is less than 20 V or 10 V, respectively (see also the following table). In this case, the power pack does not detect an internal battery and does not charge the internal battery (see the following page for flow chart).

Software in power pack	As from when is the internal battery detected?
Version H	Voltage greater than 20 V
Version I	Voltage greater than 10 V

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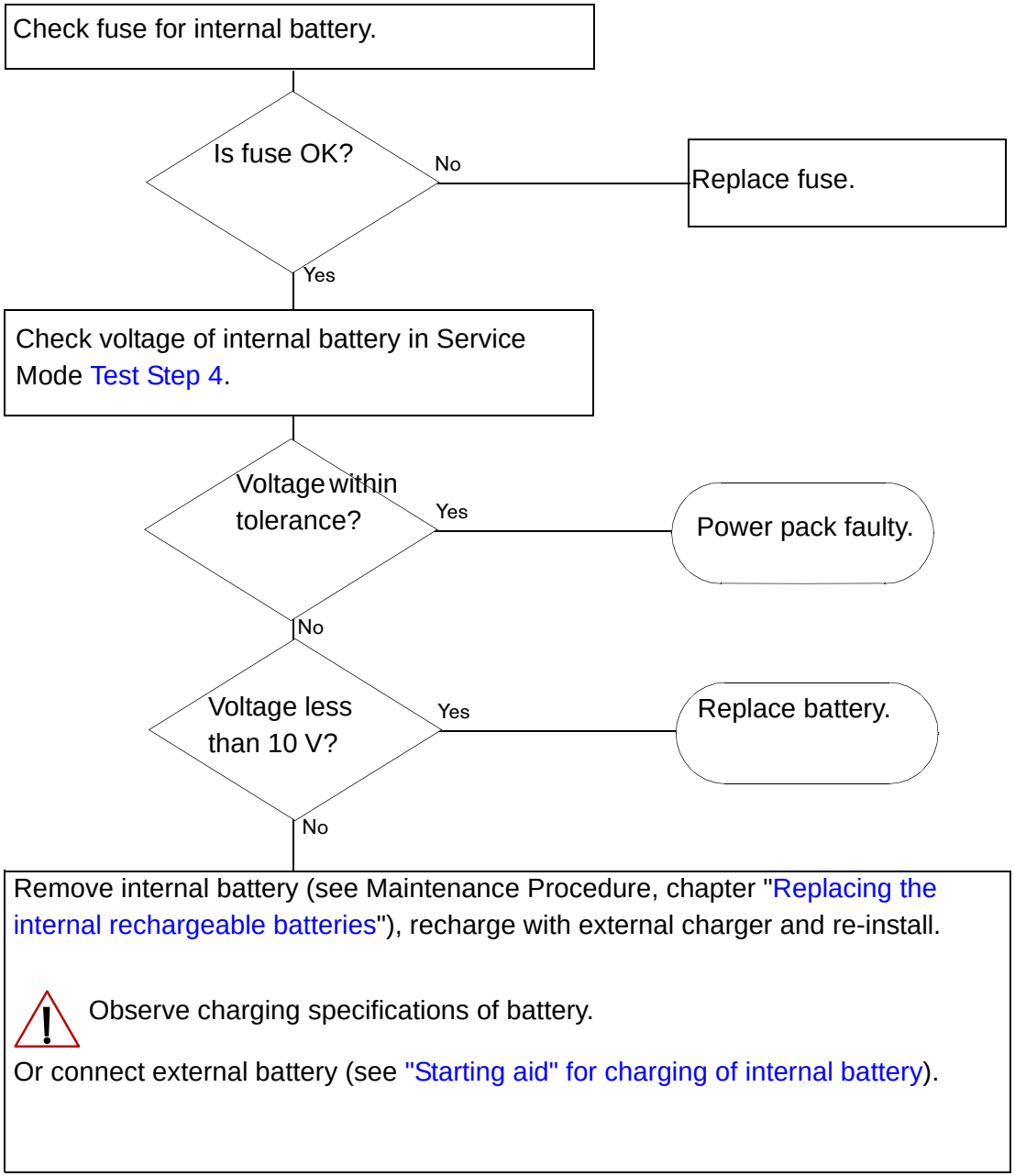
Check fuse for internal battery.
Is fuse OK?
No
Replace fuse.
Yes
Check voltage of internal battery in Service Mode Test Step 4.
Voltage within tolerance?
Yes
Power pack faulty.
No
Voltage less than 10 V?
Yes
Replace battery.
No
Remove internal battery (see Maintenance Procedure, chapter "Replacing the internal rechargeable batteries"), recharge with external charger and re-install.
Observe charging specifications of battery.
Or connect external battery (see "Starting aid" for charging of internal battery).

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"Starting aid" for charging of internal battery

For the power pack to charge the internal battery, it is sufficient to increase the battery voltage shortly above 10 V or 20 V, respectively. This can be done by applying 24 V DC to the battery.

Protect the 24 V DC voltage with an external fuse of 15 A or use a voltage supply with current limiter. Set the current limiter to 1 A.

Apply the 24 V DC voltage until the "internal battery" LED comes on (yellow) and stays on. The LED is located on the front panel of Savina.

Connect Savina to mains power supply and apply the 24 V DC voltage to the connectors as follows:

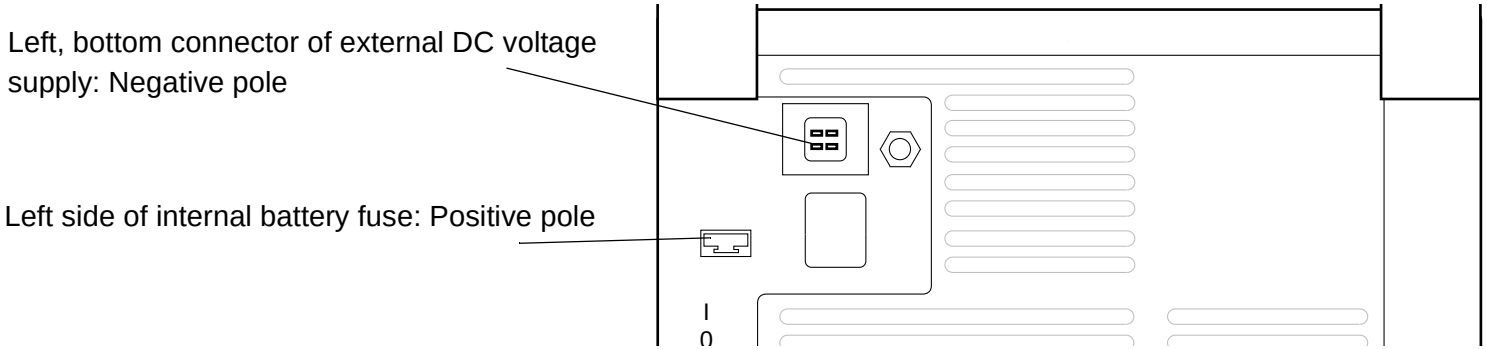

Fig.2: Rear view of external voltage supply

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Unit cannot be switched off

If the unit cannot be switched of at the ON/OFF switch, proceed as follows:

Remedy 1	**Remedy 2**
1. Set ON/OFF switch to position "OFF".	1. Set ON/OFF switch to position "OFF".
2. Press "standby" key.	2. Removing fuse of internal battery.
	3. Disconnect external d.c. supply.
	4. Unplug power plug from socket-outlet.
	5. Reconnect power supplies.
	6. Re-install fuse.

This fault may be caused by the software which does not detect the position of the ON/OFF switch. The fault should no longer occur with software version 2.n.

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Error when updating from SW 1.00 to 1.10

"BIPAP" and "Autoflow" options are lost when updating software from SW 1.00 to SW 1.10. They must be reactivated by entering the release number (release code). Activate options as follows:

1. Carry out download using SW 1.10.

2. Generate device identification number (device ID).
   In order to be able to generate the device ID you need to completely adjust the real-time clock (tt.mm.jj / hr.min). Then switch the unit off and on again, and read out the device ID from page four of the "Config." menu.

3. Write down new device ID and serial number and send them to "User Help Desk" of Intensive Care department stating the following:
   For the attention of Mr. Matthias Hurlebaus
   Note: Software update from SW 1.00 to SW 1.10
   Please send me the release codes for the "BIPAP" and "Autoflow" options:
   Address:
   Fax: (++49) 451/882 4089
   Phone: (++49) 451/882 4646
   E-mail: helptobreath@draeger.com

4. If release codes are available, activate "BIPAP" and "Autoflow" options by entering the release codes in the fourth page of the "Config" menu.

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5. Adjust the real-time clock to the real values.

6. Switch unit off and on again.

7. Check whether the "BIPAP" and "Autoflow" options are available now.

SW 1.01 to 1.10 update procedure

If the device ID in SW 1.01 has not been generated, the "BIPAP" and "Autoflow" options will be lost when updating the software from SW 1.01 to SW 1.10. If this is the case, proceed as follows:

1. Generate device identification number (device ID).
   In order to be able to generate the device ID you need to completely adjust the real-time clock (tt.mm.jj / hr.min). Then switch the unit off and on again, and read out the device ID from page four of the "Config." menu.

2. Carry out download using SW 1.10.

3. Adjust the real-time clock to the real values.

4. Check whether the "BIPAP" and "Autoflow" options are available now.

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Possible errors during O2 calibration

1. O2 sensors are faulty

   – Replace O2 sensors

2. O2 sensors have been calibrated to the wrong gas

   – Valve V4 does not open

   – R3 flow control valve is obstructed

   – Tubing at valve block are not connected properly (check using tubing diagram, see "Fig.13: Savina tubing diagram" under "Schematics and Diagrams").

   – Metal cover of O2 sensors is leaky (check sealing)

3. Measured values required for O2 calibration are incorrect (for measured values see also chapter "Service Mode")

   – Check ambient pressure sensors S6/S7

   – Check temperature measurement

   – Check internal flow measurement (S1)

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Repair Procedure

The following repair procedure is described:

- Opening the unit
- Power pack
- Motor Commutator PCB
- Fan
- O2 Diaphragm PCB
- Bypass valve V1
- Expiratory valve V3
- Replacing the EEPROM
- Replacing the Control PCB

For maintenance procedure according to Test Certificate, see Repair Instructions "Maintenance Procedure".

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Opening the unit

As required (see also "Fig.2: Front view with front panel and Control PCB folded away" and "Fig.4: Rear view of Savina with rear panel removed") Savina can be opened at the operator control panel and/or at the rear panel.

Before opening the unit, observe the following warnings:

Hazardous voltage. Touching live components can lead to serious injury or death. Before opening the unit unplug the power plug from the socket-outlet.

Electrostatic discharge may damage electrostatic sensitive devices. When handling electrostatic sensitive devices use a static-dissipative mat and a wrist strap.

– Opening the operator control panel

– Removing the rear panel

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Opening the operator control panel

Hazardous voltage. Touching live components can lead to serious injury or death. Before opening the unit unplug the power plug from the socket-outlet.

Electrostatic discharge may damage electrostatic sensitive devices. When handling electrostatic sensitive devices use a static-dissipative mat and a wrist strap.

- Switch off the unit.
- Unplug the power plug from the socket-outlet.
- Disconnect the O_2 compressed gas supply.
- Slacken the screws **1**.

Fig.1: Opening the operator control panel

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- Remove the frame of the operator control.
- Remove the screws **2** (one on the left and one on the right side).

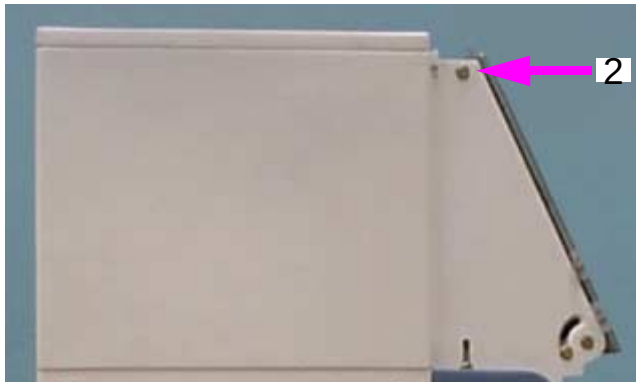

Fig.2: Folding away the operator control panel

- Fold down the operator control panel forwards.

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If necessary, for example to access the connectors of the power pack, the Control PCB can also be folded away. Fold away the Control PCB as described in the following.

- Remove the screws **3**.

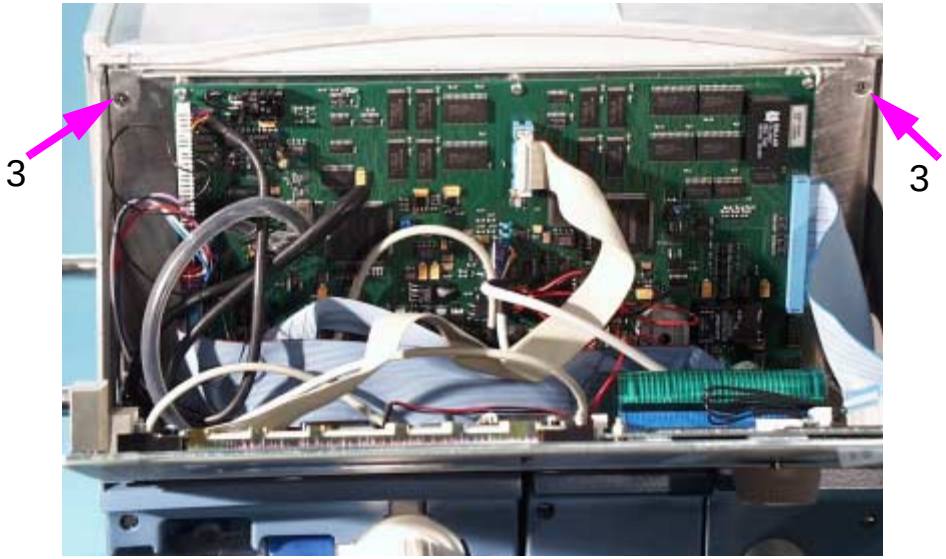

Fig.3: Folding away the Control PCB

- Fold away the Control PCB.

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Removing the rear panel

Hazardous voltage. Touching live components can lead to serious injury or death. Before opening the unit unplug the power plug from the socket-outlet.

Electrostatic discharge may damage electrostatic sensitive devices. When handling electrostatic sensitive devices use a static-dissipative mat and a wrist strap.

- Switch off the unit.
- Unplug the power plug from the socket-outlet.
- Disconnect the O_2 compressed gas supply.

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- Remove the screws **1**.

Fig.4: Removing the filter cover

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- Remove the screws **2**.

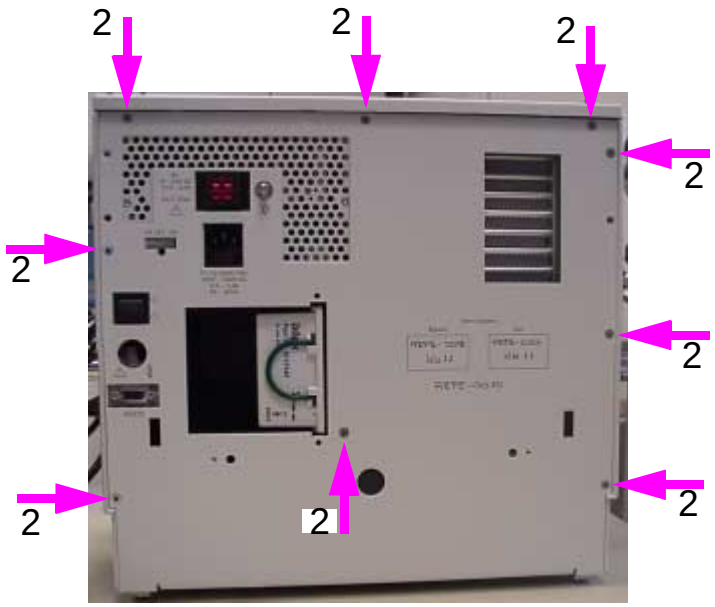

Fig.5: Removing the rear panel

- Remove the rear panel.

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When mounting the rear panel, make sure the hoses point to the left. Otherwise the hoses could buckle (which could lead to error message "O2 measurement").

Fig.6: Position of hoses

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Power pack

Measuring the supply voltages

The power pack delivers the following supply voltages:

+5 V —15 V +15 V +24 V +48 V

The +48 V are fed directly from the power pack to the Motor Commutator PCB. The remaining voltages are fed to the Control PCB and from there to the other PCBs and component devices.

The voltages can be measured on the Control PCB (except the +48 V). The operator control panel must be opened to access the measuring points (see "Opening the operator control panel"). The voltages are also displayed in Service Mode, chapter "Test Step 4".

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Voltage	Pin assignment, connector X1	Test point
+5 V	2/4	T43
DGND	1/3	T44
-15 V	11/12	T41
+15 V	8/9	T16
AGND	7/10	T39
+24 V	6	T625
AGND	5	T626
Battery	The battery voltage must be measured directly at the battery (see Maintenance Procedure, chapter "Replacing the internal rechargeable batteries"). It can also be measured between the battery fuse and the external power supply connection (see also ""'Starting aid" for charging of internal battery").	

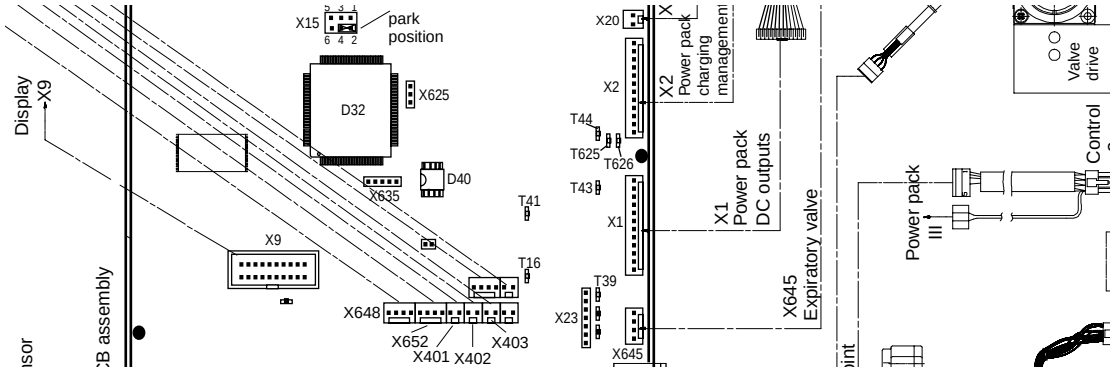

Fig.7: Voltage test points on the Control PCB

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Motor Commutator PCB

The Motor Commutator PCB is on the right behind the Control PCB (see also "Schematics and Diagrams" Fig.2:).

View of the Motor Commutator PCB

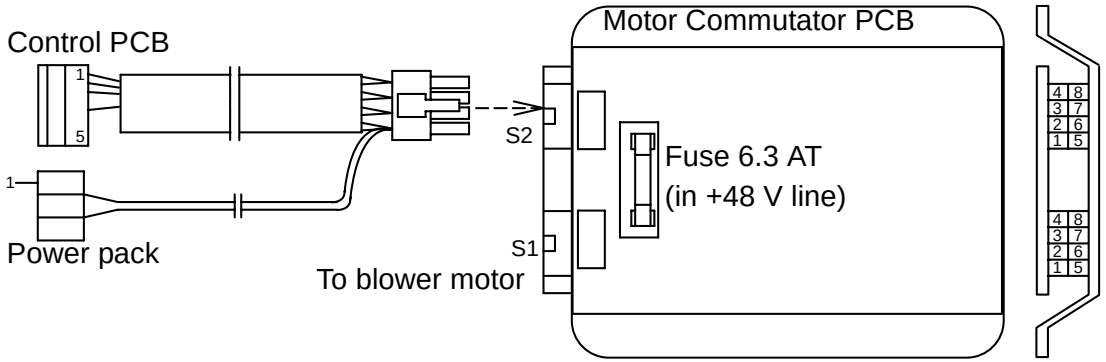

Fig.8: View of the Motor Commutator PCB

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Pin assignment of the Motor Commutator PCB

Pin	Connector S2 (to Control PCB/power pack)	Connector S1 (to blower motor)
1	Enable	Motor phase 3 (L3)
2	Operating voltage (+Ub, +48 V)	Supply to Hall sensor system (+U-Hall)
3	Not assigned	Hall signal 2 (RLG2)
4	Target speed (0 to +4.75 V)	Hall signal 1 (RLG1)
5	Not assigned	Motor phase 2 (L2)
6	Actual speed (6 pulses per revolution)	Motor phase 1 (L1)
7	Operating voltage GND	Supply to Hall sensor system (GND-Hall)
8	Target speed (-)	Hall signal 3 (RLG3)

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Fan

The fan is on the left behind the Control PCB (see also "Schematics and Diagrams" Fig.2:).

Pin assignment of the fan

Pin	Connector (to Control PCB)
1	Operating voltage (+Ub, +24 V)
2	Speed signal
3	Speed setpoint (pulse width modulation)
4	GND

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O2 Diaphragm PCB

Replacing the O2 Diaphragm PCB

The O2 Diaphragm PCB holds the mounts for the O_2 sensors and the measurement electronics. It is located directly behind the O_2 sensors. Replacement procedure:

- Switch off the unit.
- Remove the fuse for the internal battery (see Maintenance procedure, chapter "Fig.17:").
- Remove the cover of the O_2 sensors.

Fig.9: O_2 sensors cover

- Remove the O_2 sensors.

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- Remove the screws of the plastic frame.

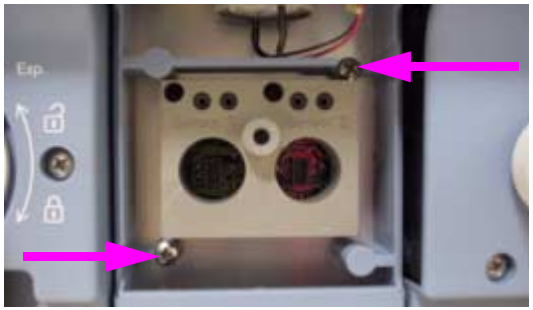

Fig.10: O_2 sensors, plastic frame

- Remove the plastic frame.

The O_2 block has tubes and cable connections. These tubes and cable connections could get damaged when removing the O2 block. Remove the O_2 block from the unit very carefully.

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- Remove the screws from the O_2 block.

Fig.11: O_2 block

- Remove the O_2 block from the unit.
- Remove the connector from the O2 Diaphragm PCB.
- Remove the fixing screws from the O2 Diaphragm PCB.

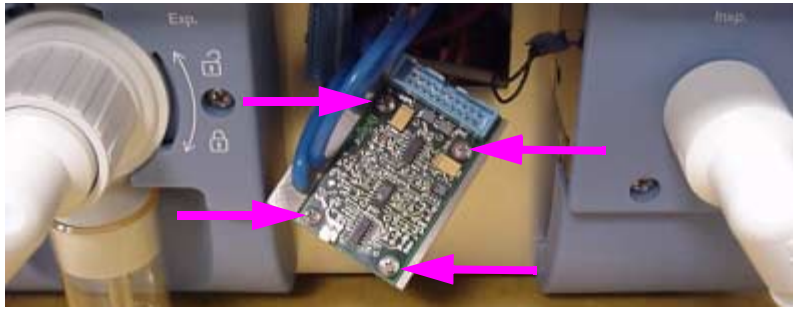

Fig.12: O2 Diaphragm PCB, position of the fixing screws

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- Mount the new 2 Diaphragm PCB
- Reassemble the unit (do not mount the O_2 sensors yet).

After replacing the O2 Diaphragm PCB, it is necessary to recalibrate the offset of the O_2 measurement electronics (see Service Mode, chapter "Test Step 22").

- Mount the O_2 sensors.
- Mount the cover of the O_2 sensors.
- Perform the safety check and functional check as per the Test Certificate.

Pin assignment of the O2 Diaphragm PCB

Only those contacts are listed for which there is a measurement result. For location of connectors, see also "Schematics and Diagrams, Fig.11:".

Pin	Connectors X1, X2
	O_2 sensors connection

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Pin	Connector X3
1	NTC in the inspiration block
2	NTC in the inspiration block (internal AGND)

Pin	Connector X4
1	+5 V
4	DGND
7/8	V_batt (approx. +24 V)
9/10	+15 V
17/20	AGND
	The values of the following signals can be read out in Service Mode (see "Service Mode, Test Step 17 through Test Step 19").
11	V_REF_O2
12	V_TEMP_O2
13	V_TEMP_AIR
14	VCC+15V_O2
15	V_FIO2_1
16	V_FIO2_1

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Pin	Connector X4
18	V_FIO2_2
19	V_FIO2_2

Bypass valve V1

After replacing the bypass valve, it is necessary to set the calibration class stated on the new bypass valve (see Service Mode, chapter "Test Step 15") and to transfer it to the rear panel (new label).

Expiratory valve V3

After replacing the expiratory valve, it is necessary to set the calibration class stated on the new expiratory valve (see Service Mode, chapter "Test Step 15") and to transfer it to the rear panel (new label).

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Replacing the EEPROM

Read the following information before replacing the EEPROM:

Do not replace the EEPROM and the RTC on the Control PCB at the same time. Otherwise the recorded operating hours will be lost. If you need to replace both components, do it in sequence, that is, complete the replacement of one component first before starting the next one.

Existing software options, for example, "BIPAP" and "Autoflow" will be lost and need to be reactivated again. You need to request the required release codes (see also the following description).

Replace the EEPROM only with a brand-new EEPROM that has not been in use before.

The unit must be off when replacing the EEPROM.

Ensure the correct polarity. If the polarity of the EEPROM is reversed the EEPROM will be destroyed. Remember the installation position of the EEPROM.

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The information stored in the EEPROM includes operating hours, software options (as of SW 1.01), device ID (as of SW 1.01), language version, volume, contrast, baud rate, and measured value display. This information must be read out and written down before replacing the EEPROM.

- Read out and write down software options (as of SW 1.01) etc.
- Switch off the unit.
- Open the unit (see "Opening the operator control panel").
- Remove EEPROM (D40) from the Control PCB.

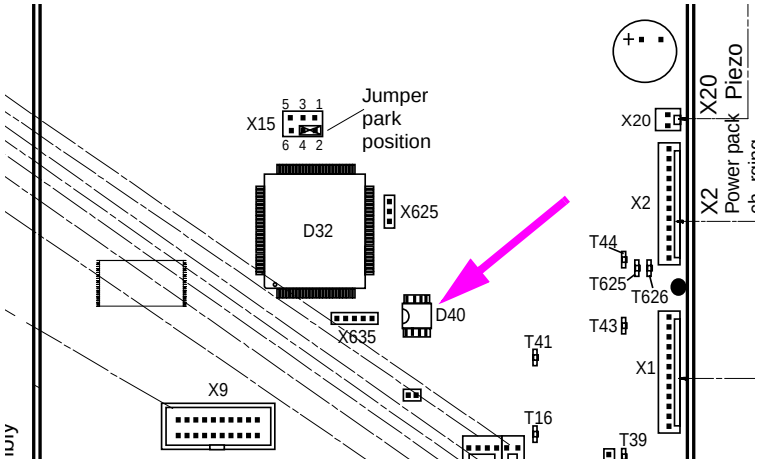

Fig.13: Removing the EEPROM

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- Install brand-new EEPROM.
- Assemble the unit.
- Switch on the unit.

A device malfunction is generated.

- Adjust settings (as written down), time, and date on the unit.

Setting the clock will generate a new device ID (see also "Error when updating from SW 1.00 to 1.10" under chapter "Repair Information/Error Events").

- Switch unit off and on again.

The unit should not generate any device malfunction. Settings recently made should be available. The operating hours should have the same status as before replacement of the EEPROM. Should O2 alarms be generated, you need to calibrate O2 sensor 2 manually (see also "Instructions for Use/Operating Instructions"). Previously detected options must be activated as described below.

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- Write down new device ID and serial number and send them to "User Help Desk" of Intensive Care department stating the following:
  For the attention of Mr. Matthias Hurlebaus
  Note: Replacement of EEPROM on Control PCB
  Please send me the release codes for the following options:
  "Enter options available before replacement of EEPROM here".
  Address:
  Fax: (++49) 451/882 4089
  Phone: (++49) 451/882 4646
  E-mail: helptobreath@draeger.com
- If release codes are available, activate "BIPAP" and "Autoflow" options by entering the release codes in the fourth page of the "Config" menu.
- Switch unit off and on again.
- Check whether options available before replacement of EEPROM here exist.
- Perform the safety check and functional check as per the Test Certificate.

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Replacing the Control PCB

Read the following information before replacing the Control PCB:

Remove EEPROM and RTC from old Control PCB and install on new Control PCB.

If SW version 1.00 is installed on the unit, update it to SW version 1.01 or higher after replacement (see also "Error when updating from SW 1.00 to 1.10" and "Download" under chapter "Repair Information/Error Events"). Otherwise the LEDs (at the front) could "flicker".

After replacement, re-enter all settings and carry out all necessary calibrations.

The unit must be off when replacing the Control PCB.

Memorize the connector pin assignment of the Control PCB.

- Switch off the unit.
- Open the unit (see "Opening the operator control panel").
- Write down the connector pin assignment (see also "Fig.8: View, Control PCB" under "Schematics and Diagrams").
- Remove the Control PCB.

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- Remove EEPROM and RTC from old Control PCB and install on new Control PCB.
- Mount the new Control PCB.
- Assemble the unit.
- Install new software, if applicable.
- Perform the safety check and functional check as per the Test Certificate.

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Software Download

Required equipment

– RS232 extension (9-pin Sub-D female on 9-pin Sub-D male connector, length: 3 m, with service coding), part number 79 01 808.

– RS232 extension RxD and TxD crossed (9-pin Sub-D female on 9-pin Sub-D male connector, length: 0,15 m, with service coding), part number 79 01 888.

– Service PC with Windows 95 or Windows NT

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In future, new versions of the service software will not run under DOS or Windows 3.n. These restrictions do not apply to version 8.n however.

Windows 95 requires at least version 8.n of service software 79 01 831.

Under Windows NT the screensaver must be deactivated, otherwise the software of the medical equipment could be damaged during downloading.
(Deactivate the screensaver (under NT4) as follows:
Right-click on your desktop and select "Properties". Click on the "Screensaver" tab and select "None" in the screensaver pull-down menu.)

If a problem occurs, do not restart Savina before the download procedure is complete.

– Service software for Windows 3.n, Windows 95 and Windows NT, part number 79 01 831.

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Download

The optional ”BIPAP” and ”Autoflow” functions will be lost when updating the software from SW 1.00 to SW 1.10 or from SW 1.01 to SW 1.10. They must be reactivated by entering the release number (release code). See also ”Error when updating from SW 1.00 to 1.10” or ”SW 1.01 to 1.10 update procedure” in chapter ”Repair Information/Error Events”.

This description applies with effect from download software 9.1.1.

- Connect Savina and PC (laptop) to mains power supply.

The Savina initial program loader could be damaged in the event of a power failure. Do not run the download if the Savina and/or the PC are being powered by battery. The battery power to the Savina is not sufficient for the download.

- Connect PC and Savina to RS232 extension and to RS232 adapter.

The software cannot be loaded with a normal RS232 cable. Pins 1 and 9 must be connected to a 10-kΩ resistor to enable the Control PCB to detect the SERVICE-Q signal. Use only the specified cables and adapters.

- Switch on the PC.

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- Start the "Service" program.

Downloading medical equipment software to PC

- Choose "Download".
- Choose "Install new device software" (if the latest software release is not yet installed on the PC).
- Insert the floppy disk with the Savina program in the A drive.
- Choose "Install".

Downloading

- Select the medical equipment software "Savina Ver. XX.XX".
- Confirm the following prompt:

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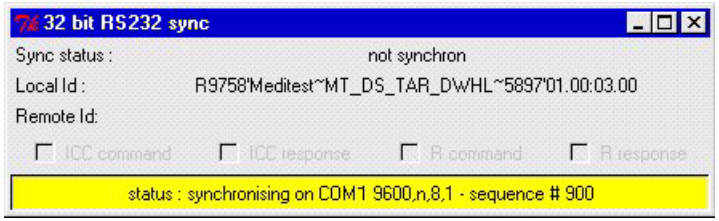
The following box appears with a yellow bar along the bottom:



- Switch on the Savina (Savina does not start up with its own operating system).

When communication has been established between the PC and the Savina the color of the bar changes from yellow to green. Then a box appears displaying contract terms.

- Confirm the disclaimer with "yes".

"Connected to Savina" is displayed.

- Switch off Savina.
- Use the Up or Down arrow keys on the PC to select "downloadrequest", or type in "downloadrequest".
- Press {Enter}.
- Press {Enter} to start the download or {Esc} to cancel.

The following window appears:

Download files for version: XX

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Selected	ID number	Description
X	XA	XN. DLD "SW-Front"
X	XB	XM. DLD "SW-Master"

The download can be run singly or in batch mode. There is one download for the Front Processor and one for the Master Processor. An "X" in the "Selected" column indicates that the download in question is selected.

- Press {Enter}.

The download is now executed. Information on the download is displayed on the PC screen. The entire download takes around 15 minutes and is concluded when the following message appears on the PC screen:

Result:	Transfer of requested files completed.

- Exit the program on the PC with {Esc}.
- Cut the connection between the PC and Savina.

If Savina is equipped with software version 1.96, carry out steps 1 through 5 directly. These steps apply to this software version only.

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- Switch on Savina.
- Press the "Standby" key.

1. Remove the fuse for the internal battery (see "Fig.17: in the maintenance procedure" section).
2. Cut the power supply to the Savina.
3. Restore the power supply to the Savina.
4. Re-insert the fuse for the internal rechargeable battery.
5. Switch on Savina.

The Savina starts up with its own operating system. No error messages must appear.

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Settings such as the time are not affected by the download because they are stored in the real-time clock on the Control PCB.

A supply failure during the download could destroy the initial program loader on the relevant PCB. The software must then be downloaded with the hardware-oriented interface (see "Bootstrap download").

If the download will not start, check the RS232 cable and/or make sure you have selected the correct COM port.

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Bootstrap download

The software only needs to be downloaded with the hardware-oriented interface (bootstrap download) when the initial program loader on the PCBs has been destroyed by a power supply failure during the download.

Before opening the unit, observe the following warnings:

Hazardous voltage. Touching live components can lead to serious injury or death. Before opening the unit unplug the power plug from the socket-outlet.

Electrostatic discharge may damage electrostatic sensitive devices. When handling electrostatic sensitive devices use a static-dissipative mat and a wrist strap.

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Required test equipment

– Service PC with Windows 95 or Windows NT.

– "Bootstrap Download" service program (part number 79 10 697).

– Savina bootstrap cable (part number 79 10 951).

– RS232 extension with service coding, part number 79 01 808

– RS232 adapter with service coding, part number 79 01 888

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Installation and use of the bootstrap download program

- Connect Savina and PC to the mains power supply.

The Savina initial program loader could be damaged in the event of a power failure. Do not run the bootstrap download if the Savina and/or the PC are being powered by battery. The battery power to the Savina is not sufficient for the download.

Under Windows NT the screensaver must be deactivated, otherwise the software of the medical equipment could be damaged during downloading.

- Connect the PC to the RS232 extension.
- Connect the Savina to the RS232 adapter.
- Interconnect the RS232 extension and the RS232 adapter.

The software cannot be loaded with a normal RS232 cable. Pins 1 and 9 must be connected to a 10-kΩ resistor to enable the Control PCB to detect the SERVICE-Q signal. Use only the specified cables and adapters.

- Install the "Bootstrap Download" service program on the PC.

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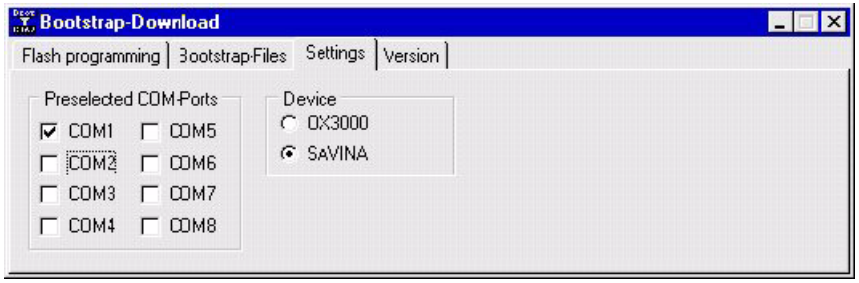
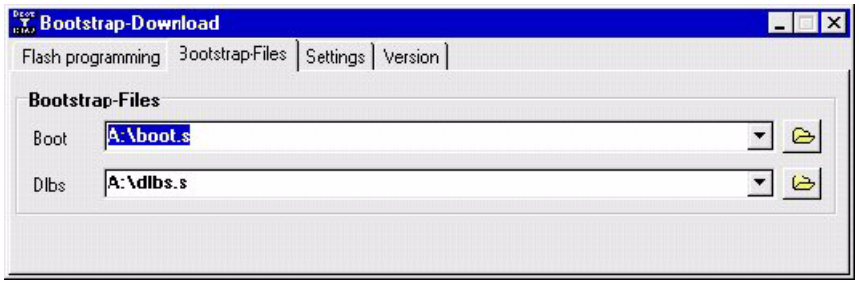
- Start the bootstrap download program.
- From the "Settings/Preselected COM-Ports" menu select the correct COM port.
- From the "Settings/Device" menu select Savina.



- Under the "Bootstrap-Files/Boot" menu enter the path of the "boot.s" file.
- Under the "Bootstrap-Files/Dlbs" menu enter the path of the "dlbs.s" file.

The files are located on the download floppy.



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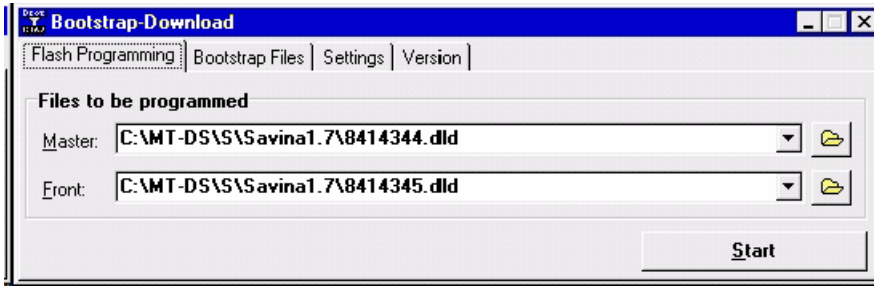
- Under the "Flash programming/Master" menu enter the path of the "8414344.dld" file.
- Under the "Flash programming/Front" menu enter the path of the "8414345.dld" file.



- Switch off Savina.
- Cut all the power to the Savina:
  - Pull the power plug.
  - Remove the fuse for the external battery (see also "Fig.17: in the maintenance procedure" section).
  - Cut any power from an external battery or from the on-board power supply.
- Open the Savina operator control panel (see also "Opening the operator control panel" in the "Repair procedure" section).
- Plug a jumper onto pins 5 and 6 of connector X14 and another one onto pins 5 and 6 of connector X15 on the Control PCB (see also "View, Control PCB" in the "Schematics and Diagrams" section).

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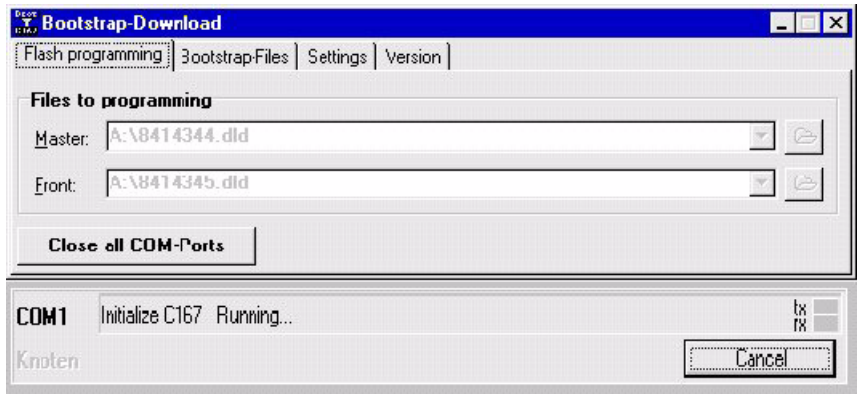
- Plug the power plug into the mains socket-outlet.
- Switch on Savina.

Savinagenerates audible alarm.

- In the bootstrap download program choose "Start".
- Switch off Savina.

The audible alarm should stop. The display should be bright.

The following window appears:



On completion the above window shows: "COM1 Ready" "Front 100%".

- In the bootstrap download program choose "Close all COM PORTS".

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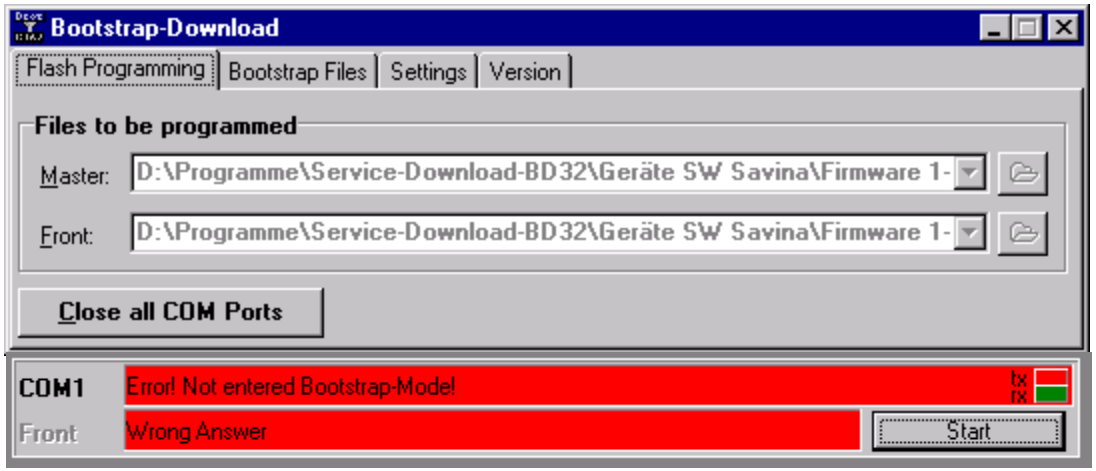
- On the Control PCB remove connector X71 ("View, Control PCB" in the "Schematics and Diagrams" section).
- Connect the Savina bootstrap cable to connector X71 and the multiple socket outlet X71 on the Control PCB.
- In the bootstrap download program choose "Start".

If the following error occurs, proceed as follows. Otherwise continue with "Data transfer takes about 10 minutes." on page 317:



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- Cut all the power to the Savina:
  - Pull the power plug.
  - Remove the fuse for the external battery (see also "Fig.17: in the maintenance procedure" section).
  - Cut any power from an external battery or from the on-board power supply.
- After a short time, reconnect the power plug.
- Switch on Savina.

Savinagenerates audible alarm.

- In the bootstrap download program choose "Start".
- Switch off Savina.

Data transfer takes about 10 minutes.

As soon as the data transfer is complete:

- Pull the power plug.
- Remove the Savina bootstrap cable.
- Unplug the jumpers from pins 5 and 6 on connector X14 and from pins 5 and 6 on connector X15 and return them to their original positions on the Control PCB.

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- Assemble Savina.
- Insert the fuse of the external battery and restore any power feed from an external battery or from the on-board power supply.
- Perform the safety check and functional check as per the Test Certificate.

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Software Versions

Overview of the different software (SW) versions

Explanation of the version:

invalid:	This software version is approved, but should not be used because it no longer reflects the latest version. An updated version should be installed when the next repair work or inspection takes place.
current:	This software is both approved and the most current version.
approved:	This software is approved but not a current version. Conversion is only necessary if improvements are desired.
not approved:	This software version is not approved in a specific country or region and is, thus, NOT to be used.

Software version	Status
SW 1.96	invalid
SW 1.00	approved
SW 1.01	approved
SW 1.10	current

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Description of changes

Software version	Changes
1.96	Version for handling test. The SW does not contain the full functions as the serial SW.

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Software version	Changes
1.00	First series SW for Savina. Improvements to SW 1.96: – New Instructions for Use – Oxygenation for bronchial suction is new – Drug nebulizer function is available – AutoFlow function is new – Improved O_2 calibration – Only parameter "FlowAcc" available now, parameter "Ramp" is no longer available – Medibus log at serial interface now available – Parameter "V_T" as of 50 mL adjustable – Internal service mode now available

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Software version	Changes
1.01	Improvements to software version 1.00: – Control of piezo alarm by safety Software (SiSW) has been revised. – Tolerance of SiSW for monitoring of supply voltage to O2 sensors has been extended. – The SW has been adapted to component tolerances on the Control PCB.
1.10	– Generation of a device identification number (device ID) by initial setting of date and time. – Handling of optional ”BIPAP” and ”Autoflow” functions implemented by entry of a release code. – Internal service mode has been adapted. – New languages added (Japanese, Russian, Greek, Romanian). – Differentiation between the following alarms has been integrated: “!!! Temperature high”: This alarm is triggered by the sensor in the inspiration block. “!!! Breathing gas temp. high”: This alarm is triggered by the AWT 01 sensor.

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Schematics and Diagrams

Front view Savina

Fig.1: Front view Savina

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Fig.2: Front view with front panel and Control PCB folded away

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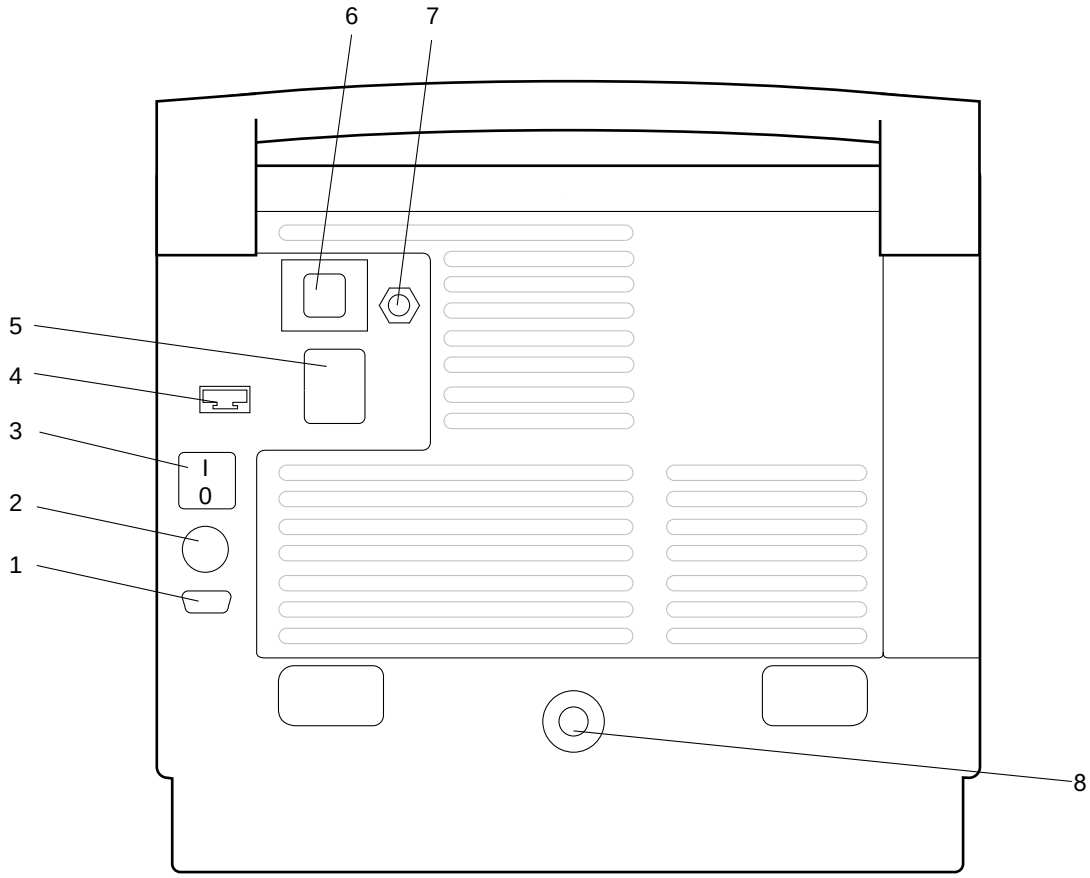
Rear view of Savina



Key to Fig.3: Rear view of Savina			
1	MEDIBUS interface	5	Mains power connection
2	Nurse call	6	Direct voltage socket
3	Power switch	7	Ground stud
4	Fuse of rechargeable batteries	8	Oxygen concentrator connection (not yet available)

Fig.3: Rear view of Savina

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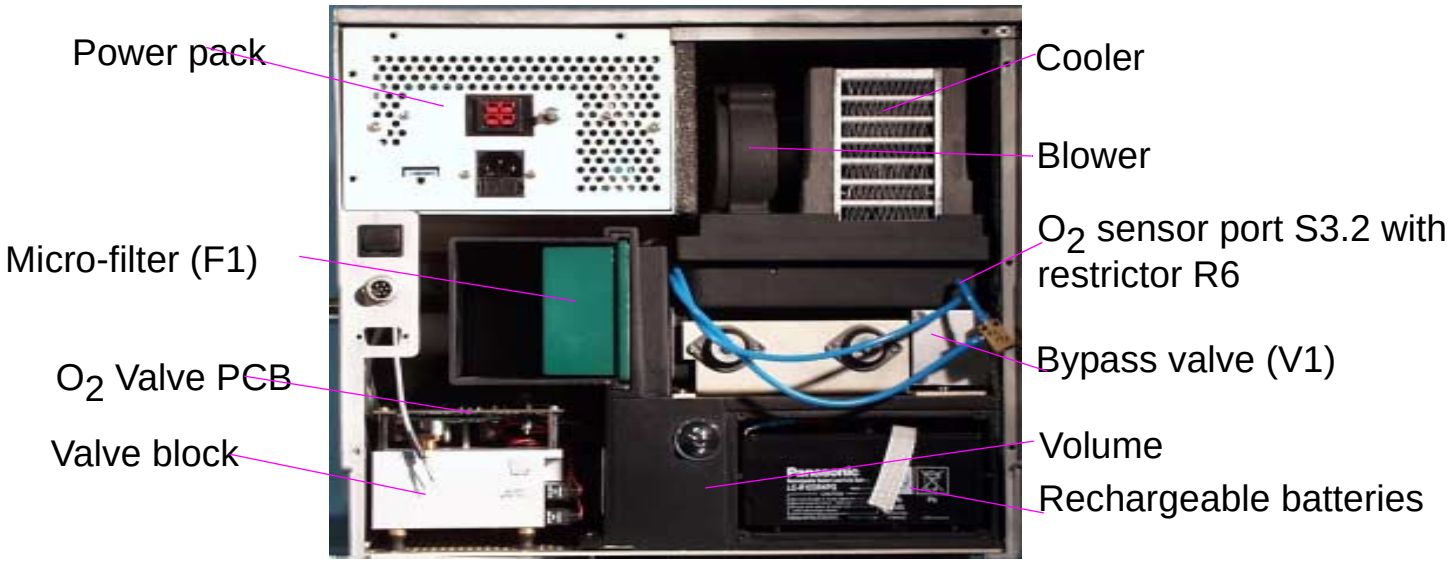

Fig.4: Rear view of Savina with rear panel removed

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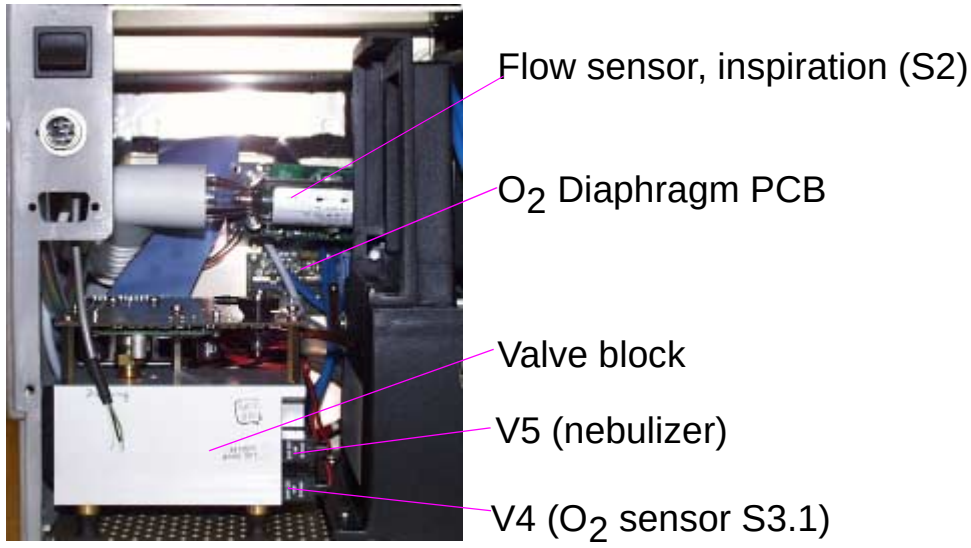

Fig.5: Rear view with micro-filter and its housing removed

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Identification of PCBs

O_2 Valve PCB

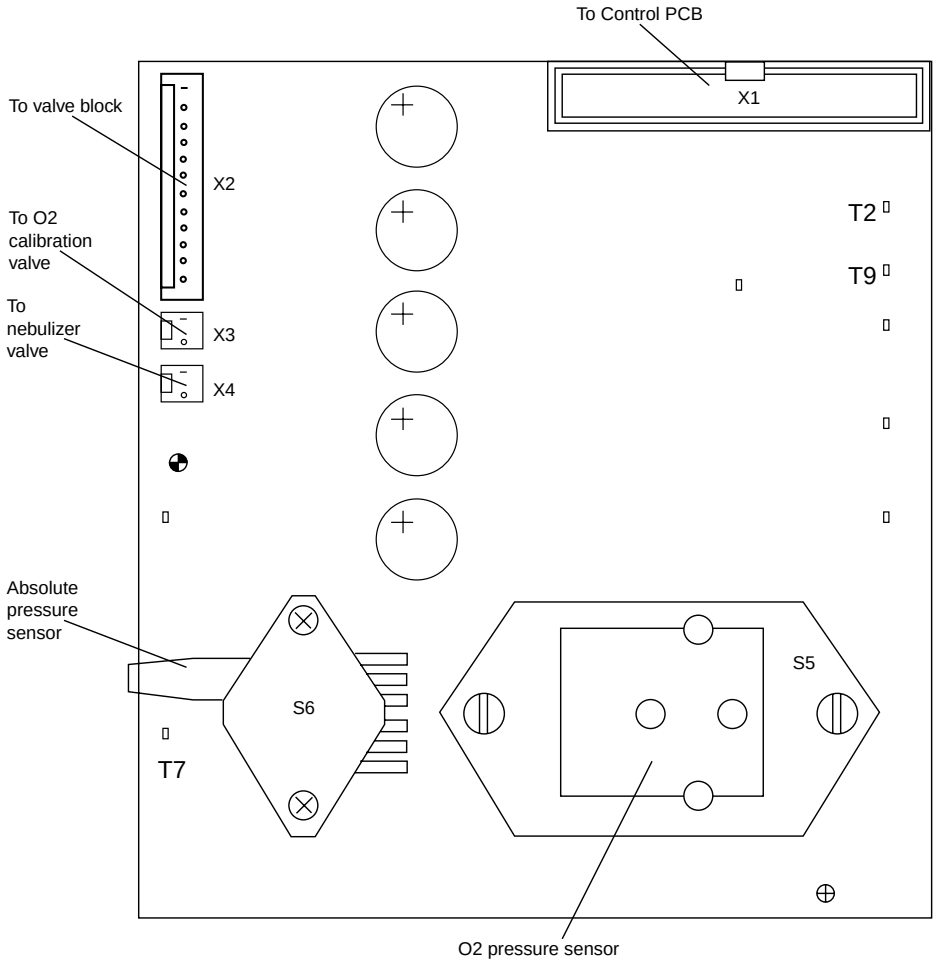

Fig.6: View 1, O_2 Valve PCB

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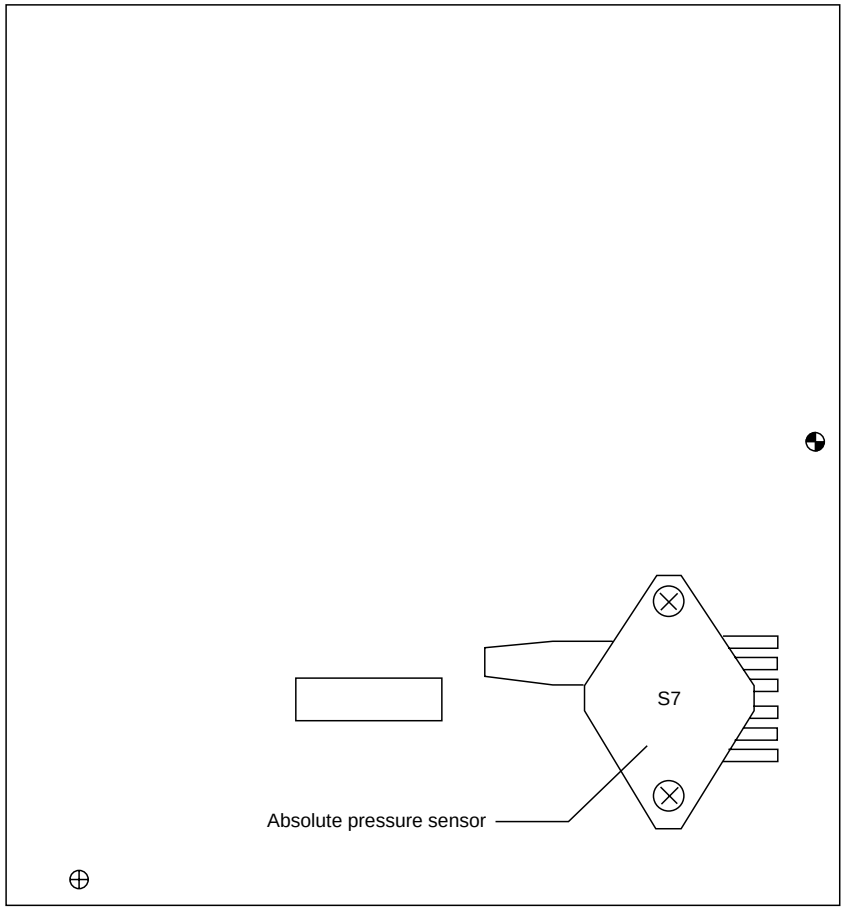

Fig.7: View 2, O_2 Valve PCB

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Control PCB

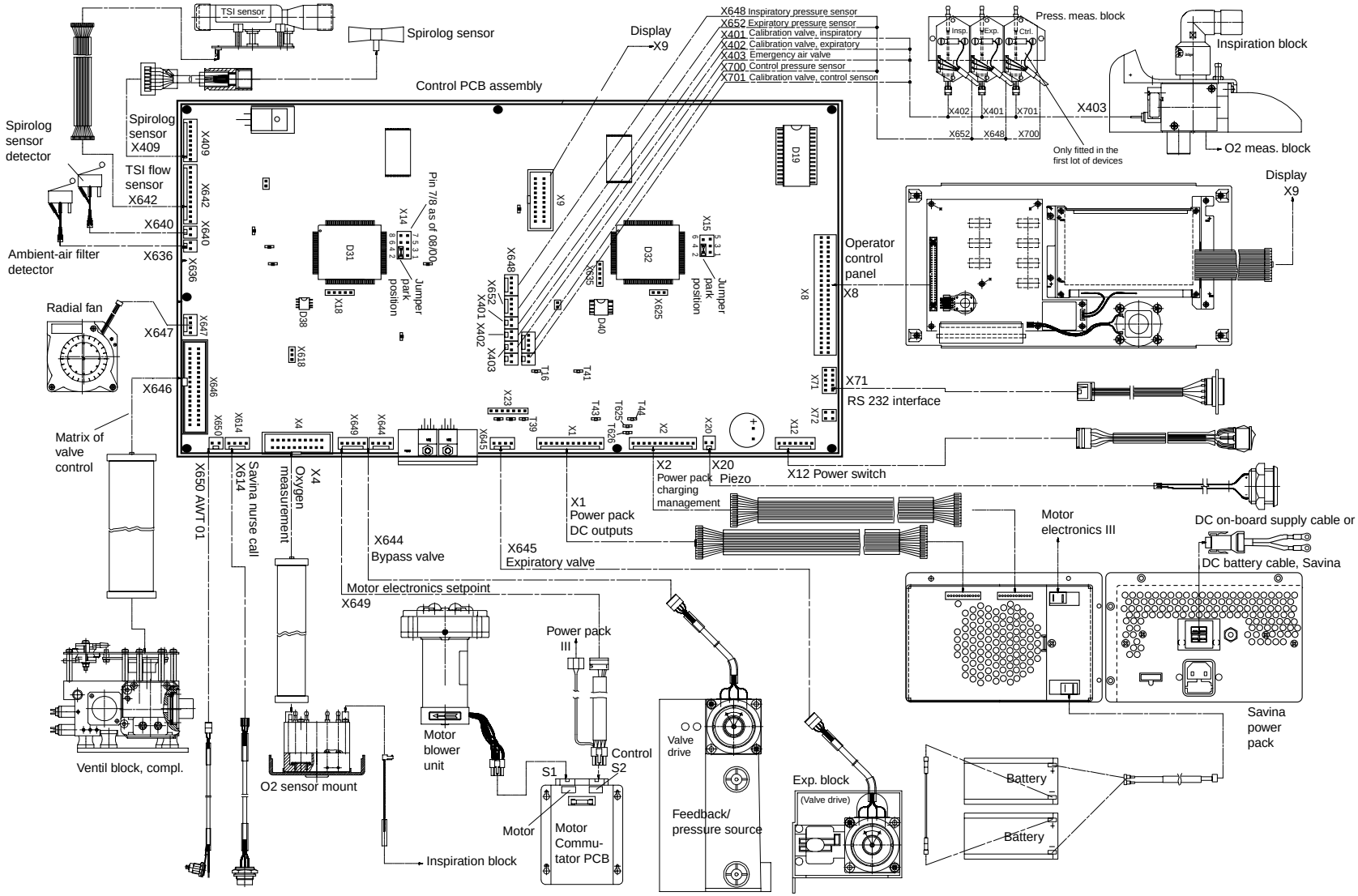

Fig.8: View, Control PCB

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Front Panel PCB

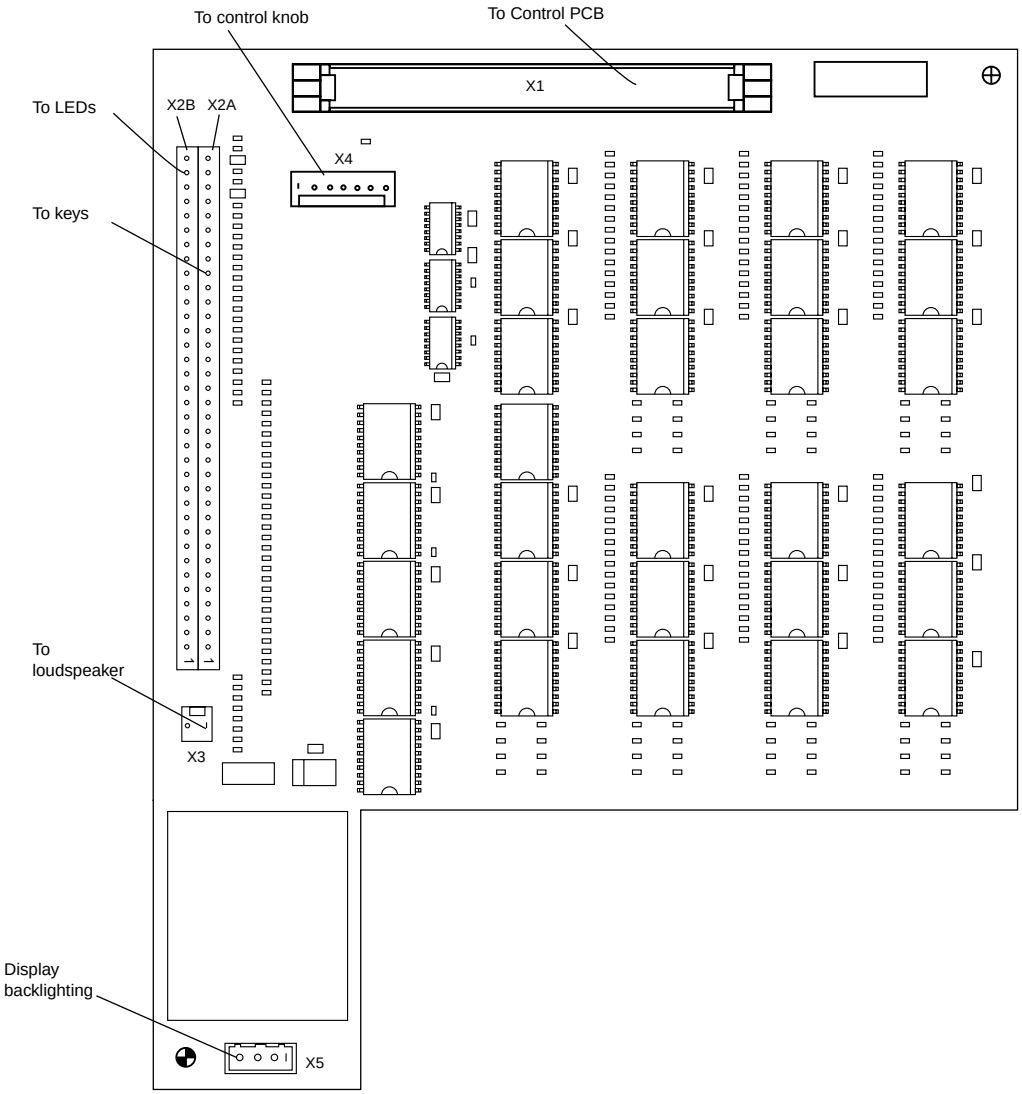

Fig.9: View 1, Front Panel PCB

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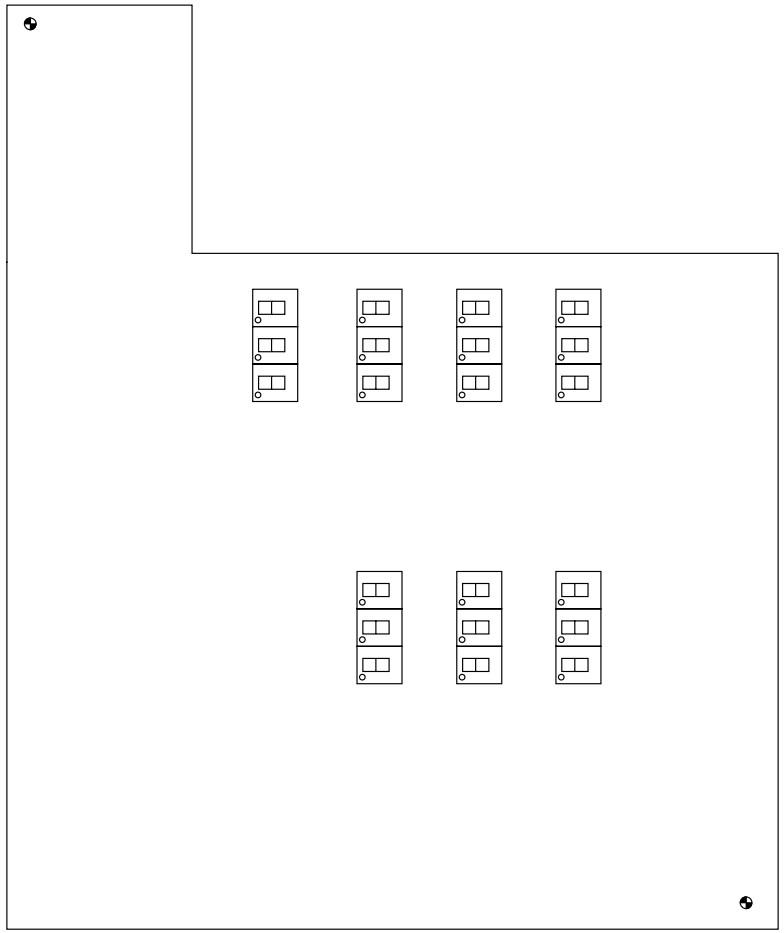

Fig.10: View 2, Front Panel PCB

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O_2 DiaphragmPCB

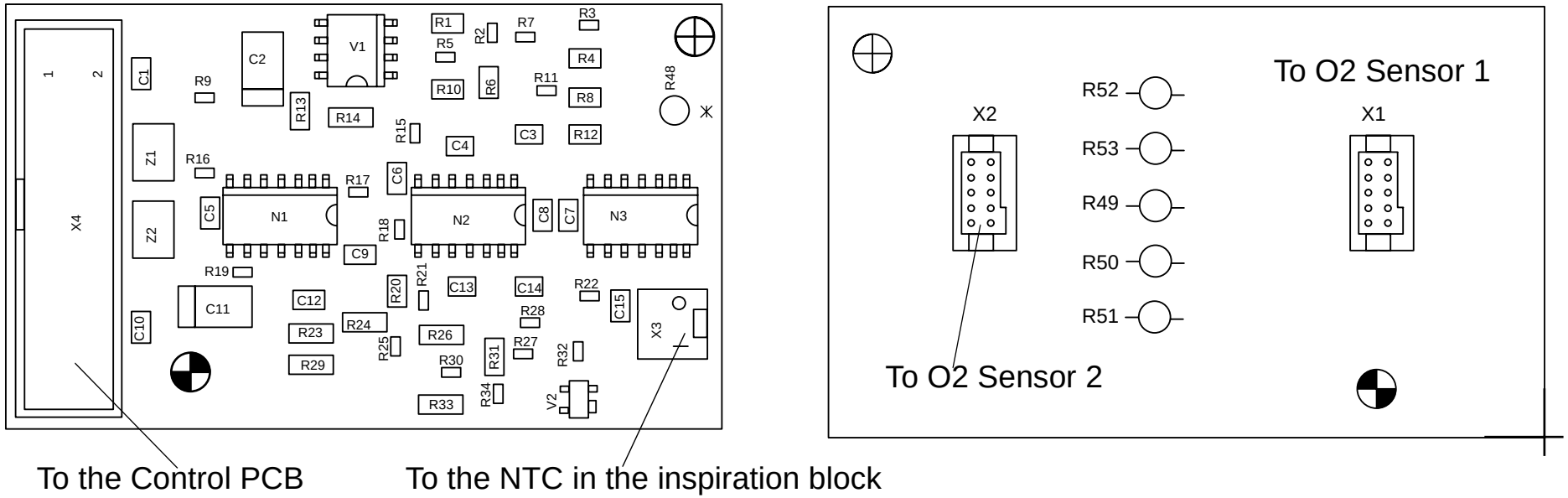

Fig.11: O_2 Diaphragm PCB

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Pneumatic diagram

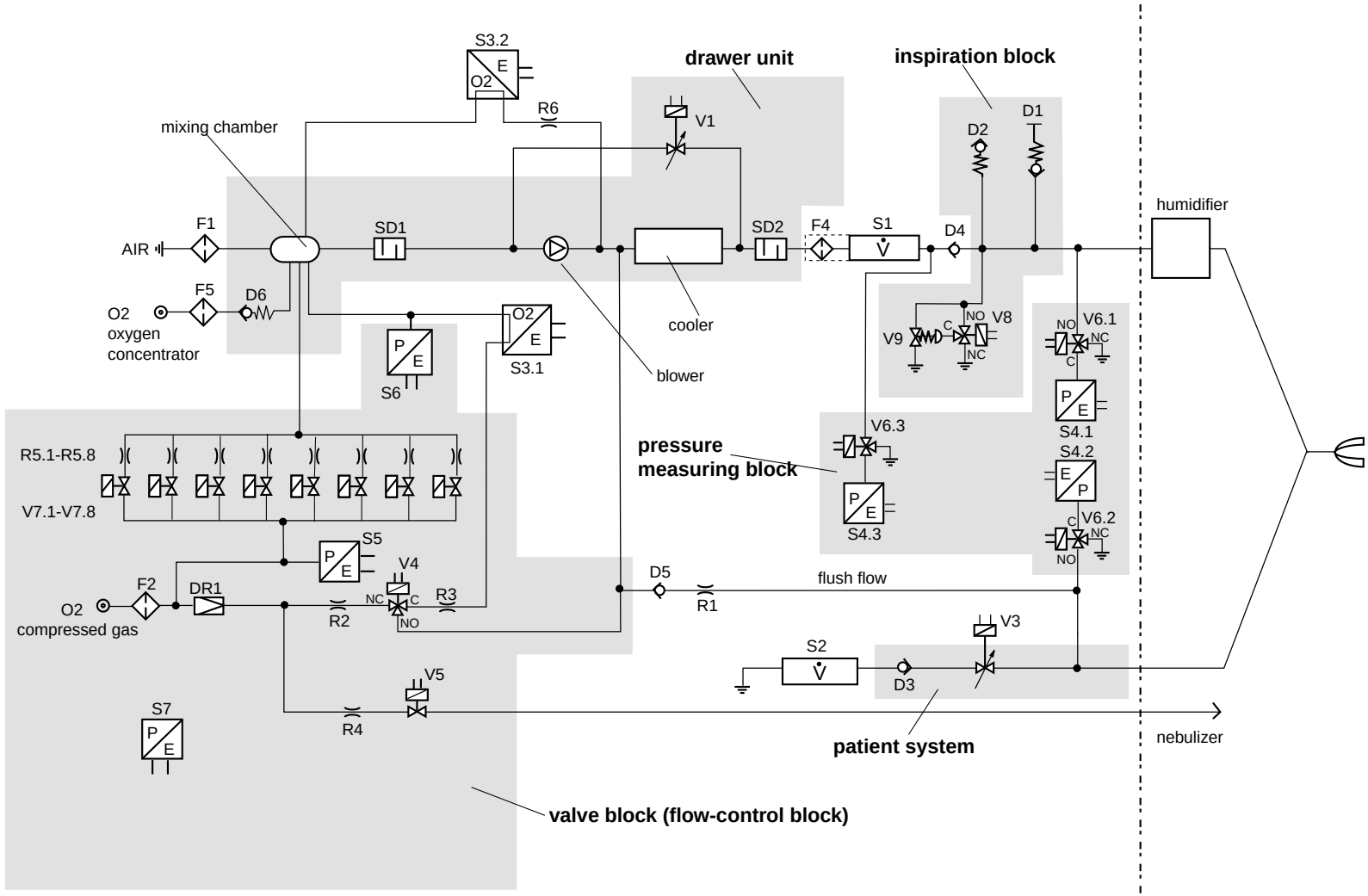

Fig.12: Pneumatic diagram

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Savina tubing diagram

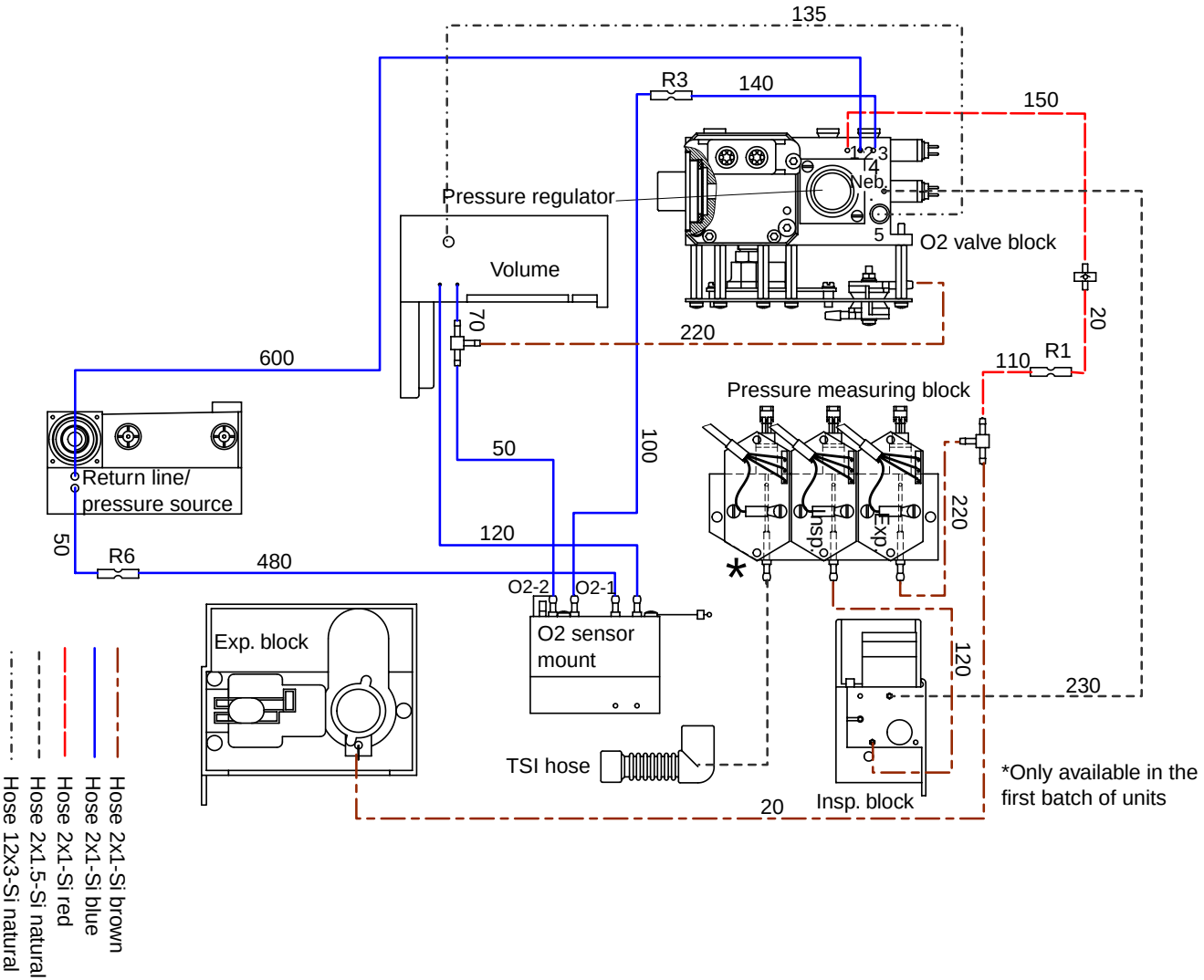

Fig.13: Savina tubing diagram

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Function Description

General

Savina is a long-term ventilator unit designed for patients with a tidal volume of 50 mL and above, and for the following applications:

– Intensive care unit

– Recovery room

– Secondary transportation from hospital to hospital

– Patient transfer within the hospital

– Transfer flights

Working principle

Savina generates the compressed air for ventilation with a blower, which means Savina is able to ventilate without any connection of compressed air or oxygen. A controllable valve is switched in parallel with the blower to regulate the pre-set ventilation parameters. The valve opens or closes according to the pre-set ventilation parameters.

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To increase the oxygen concentration in the ventilatory gas, an oxygen concentrator, such as Permox® SilentCare from Dräger Medizintechnik GmbH, can be connected.[1] If compressed oxygen is connected to Savina, the oxygen concentration of the ventilatory gas can be precisely metered. The oxygen concentration is then metered internally with sensors, the associated electronics, and a bank of valves.

Monitoring

Savina has the following monitoring:

– Measurement of the airway pressure (Paw)

– Measurement of the expiratory minute volume (MV)

– Measurement of the inspiratory O_2 concentration (FiO_2)

– Measurement of the inspiratory gas temperature (T)

– Detection of a period of apnea

– Detection of dead space-intensive spontaneous breathing (tachypnea monitoring).

1. Not yet implemented.

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Principal components

Savina consists of the electronics, the operator control unit and the pneumatic system, containing the following principal components:

Electronics:

- Power pack
- Control PCB
- Motor Commutation PCB
- O2 Valve PCB
- O2 Diaphragm PCB
- Fan

Operator control panel

- Front Panel PCB
- Display
- Membrane keypad
- Control knob

Pneumatics:

- Drawer unit
- Valve block
- Inspiration block
- Pressure measuring unit
- Patient system
- Flow sensors

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Electronics

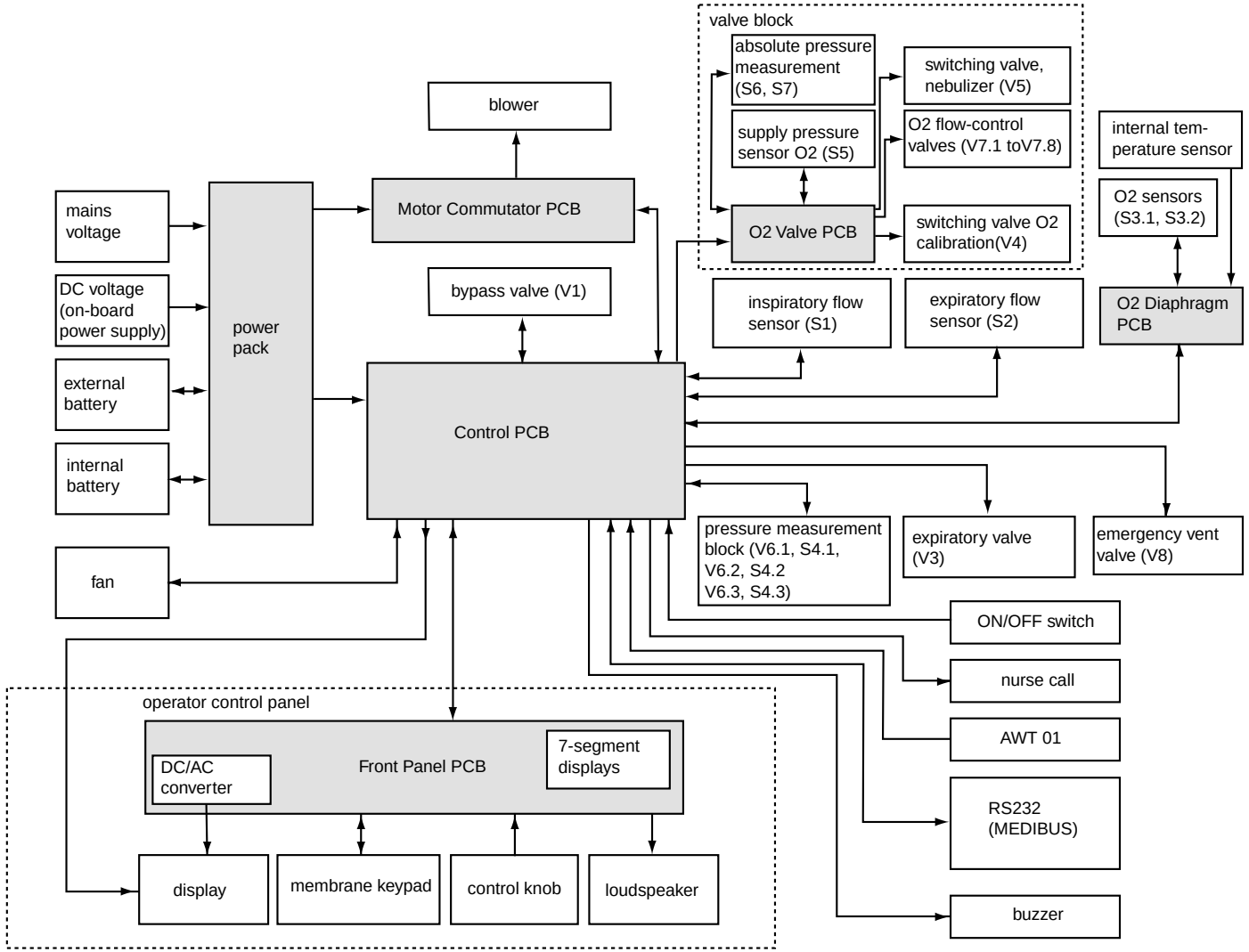

Fig.1: Block diagram of the electronics with operator control

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Power pack

The power pack delivers the supply voltages for Savina. The input voltage range of the power pack is 100 V to 240 V AC and 50 Hz to 60 Hz. However, the power pack can also be operated with an external rechargeable battery (12 V or 24 V) or with an external on-board - ambulance/helicopter - power supply (10 V to 36 V).

The connection for the alternating voltage is made by a power cable. The connection for the external rechargeable battery or the external on-board power supply is made by a coded plug.

The power pack actuates the three ”Mains power”, ”External battery or on-board power supply” and ”Internal battery” LEDs. The LEDs are mounted on the membrane keypad of the operator control, and indicate the current operating status.

Savina includes 2 internal rechargeable batteries (2 x 12 V) which enable uninterrupted operation in the event of a complete failure of external power. The internal rechargeable batteries supply the O_2 sensors with power, even when the Savina is switched off. As a result, valid O_2 values are available immediately on power-up.

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The power pack delivers the following output voltages:

– +5 V

– —15 V

– +15 V

– +24 V

– +48 V

The output voltages are short-circuit-proof and stable at no-load.

The output voltages are generated according to the following priority, dependent on the input voltages:

Input voltage	Priority	Action
AC voltage	1	Charge external and internal batteries, and maintain the charge.
External on-board power supply	2	Charge internal batteries, and maintain the charge.
External battery/batteries	3	Maintain the charge of the internal batteries.
Internal batteries	4	—

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The fan cools the power pack. The heated air removes excess oxygen from the control unit and warms the patient system.

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Control PCB

The Control PCB is the central ”control and monitoring unit” of the Savina. It includes two separate processor systems: the master and front processors. The program memories are Flash-EPROMs. The Flash-EPROMs can be programmed with a laptop connected to the serial port of the Savina (software download).

An EEPROM is provided for each processor system for storage of changeable, non-volatile data. The EEPROM of the master stores the calibration data of the sensors, fan, etc. The EEPROM of the front processor stores safety parameters, settings such as contrast, sound volume, etc., as well as a "backup copy" of the operating hours. The EEPROM of the front processor is plugged in and, if the board needs to be replaced, must be mounted on the new board.

The board is provided with a real-time clock which is used to display the time and to store the software options, the unit identification and the operating hours. The real-time clock is buffered by a battery which is integrated in the real-time clock. The real-time clock also holds the logbook. The real-time clock is plugged in and, if the board needs to be replaced, must be mounted on the new board.

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The Control PCB contains the following functions:

– Processing of the signals from the sensors (O_2, flow, pressure, temperature)

– Control of the blower and valves

– Monitoring of the unit functions and the supply voltages

– Actuation of the displays

– Keypad interpretation

– Delivery of the internal and external interfaces.

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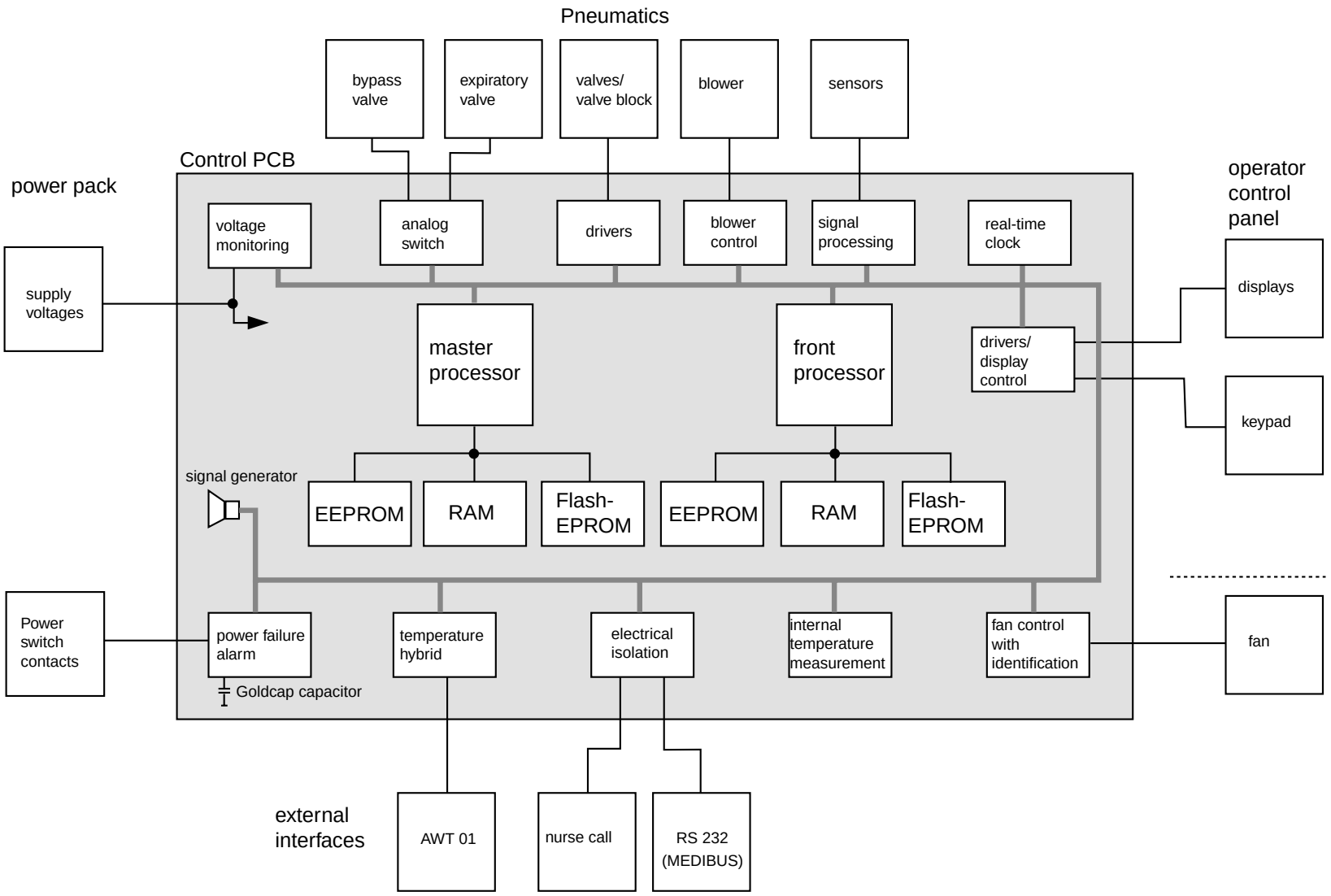

Fig.2: Block diagram of the Control PCB

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Motor Commutation PCB

The Motor Commutation PCB controls the motor of the blower. The entire control functionality is located in a self-contained housing. The supply voltage is +48 V, and is delivered by the power pack. The +48 V on the Motor Commutation PCB are protected with a fuse (6.3AT).
The input voltage range of the Motor Commutation PCB is 12 to 52.5 V. The rotation speed is set by the Control PCB. The control voltage for the rotation speed is 0 to +4.75 V, corresponding to a rotation speed of 0 to 12.500 rpm. The rotation speed range is 300 to 12.500 rpm.
The Motor Commutation PCB delivers the ”actual rotation speed signal” to the Control PCB. The "actual value signal" is 6 pulses per rotation. In the event of discrepancies in the rotation speed the Control PCB adjusts the speed according to the deviation.

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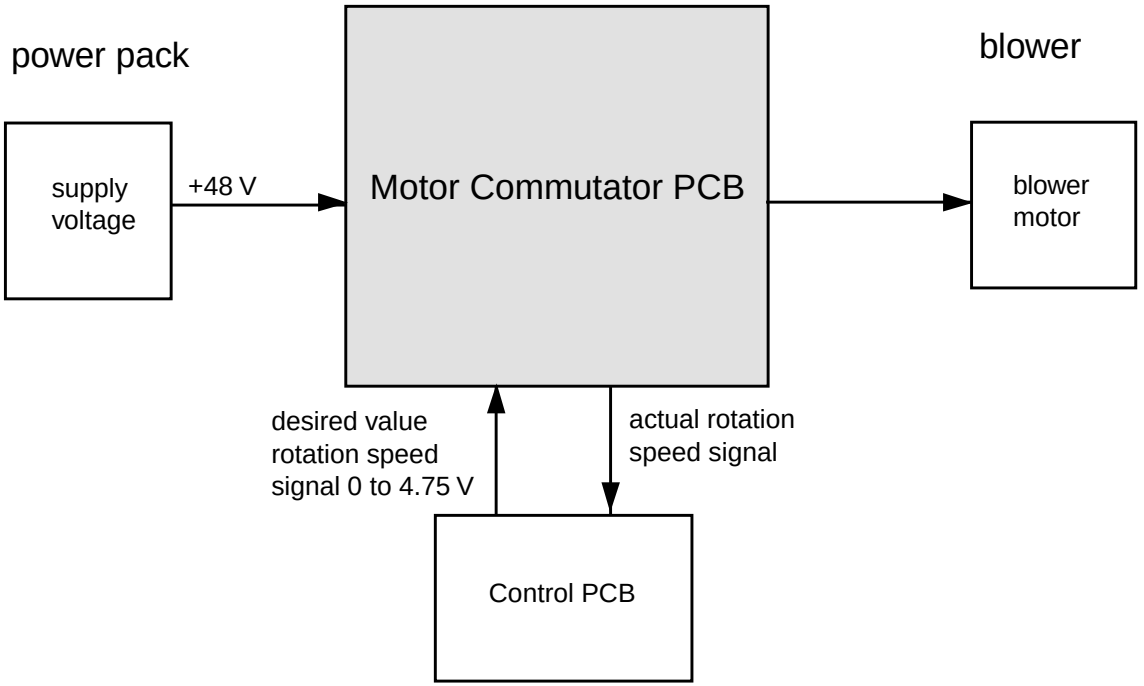

Fig.3: Block diagram of the Motor Commutation PCB

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O_2 Valve PCB

The O_2 Valve PCB holds the pressure sensors (2x absolute pressure S6 and S7, 1x O_2 supply pressure S5), the actuator for the O_2 calibrating valve and the nebulizer valve, and the actuator for the valve block.

The signals from the pressure sensors are amplified and passed to the Control PCB. The +5 V voltage supply to the pressure sensors is generated on the O_2 Valve PCB.

The valves in the valve bank, the O_2 calibrating valve and the nebulizer valve can be operated individually by an electronic switch. They are actuated by the Control PCB.

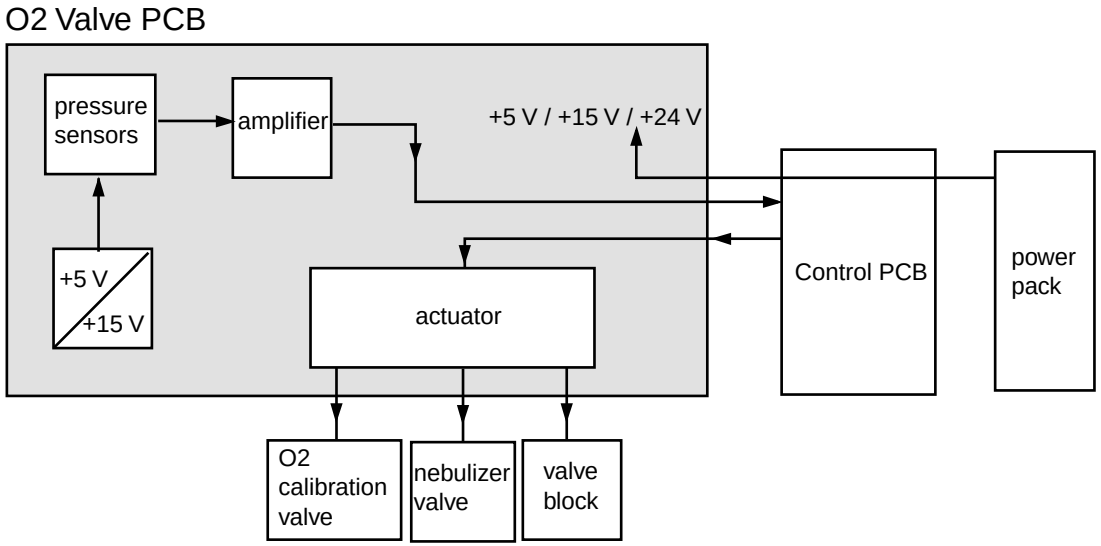

Fig.4: Block diagram of the O_2 Valve PCB

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O_2 Diaphragm PCB

The O_2 Diaphragm PCB amplifies the signals from the O_2 sensors and measures the temperature of the O_2 sensors and of the respiratory gas in the inspiration block. The temperature of the O_2 sensors is required to compensate for the temperature-sensitive O_2 measurements. The calibration data from the sensors are stored on the Control PCB in an EEPROM. The reference voltage of the O_2 sensors is generated from the voltage of the rechargeable batteries, and so is also available when the unit is switched off.

The operating voltages of the O_2 Diaphragm PCB are +5 V and +15 V.

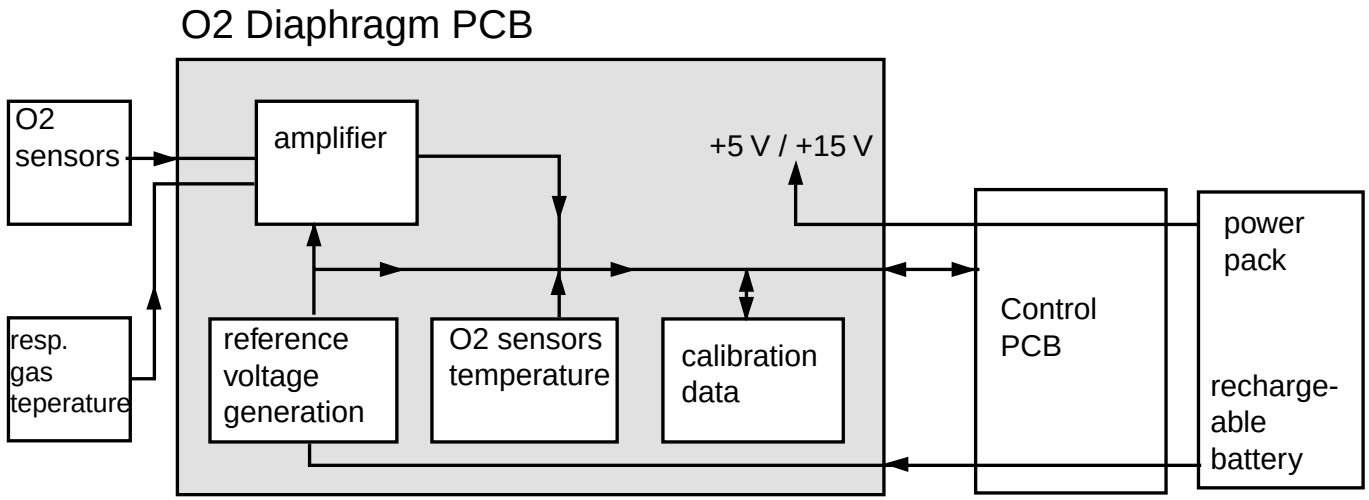

Fig.5: Block diagram of the O_2 Diaphragm PCB

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Fan

The fan takes in ambient air through the cooler of the blower and cools the blower. The air flow also removes excessive oxygen from the device.

The voltage supply to the fan is +24 V. The rotation speed of the fan is controlled by the Control PCB.

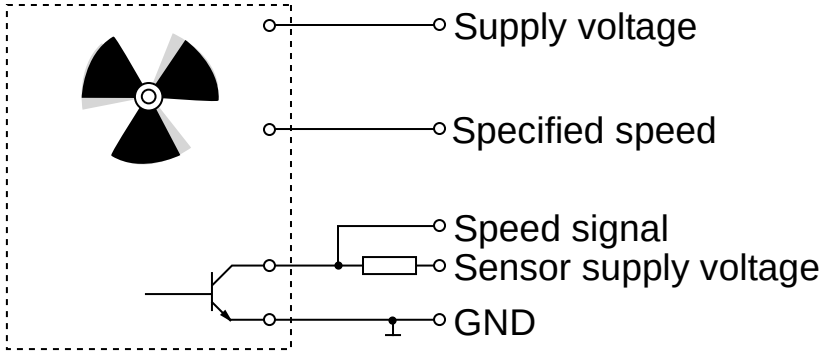

Fig.6: Fan control

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Operator Control Panel

The operator control panel is the interface between the unit and the user. It is used to enter and display the ventilation parameters.

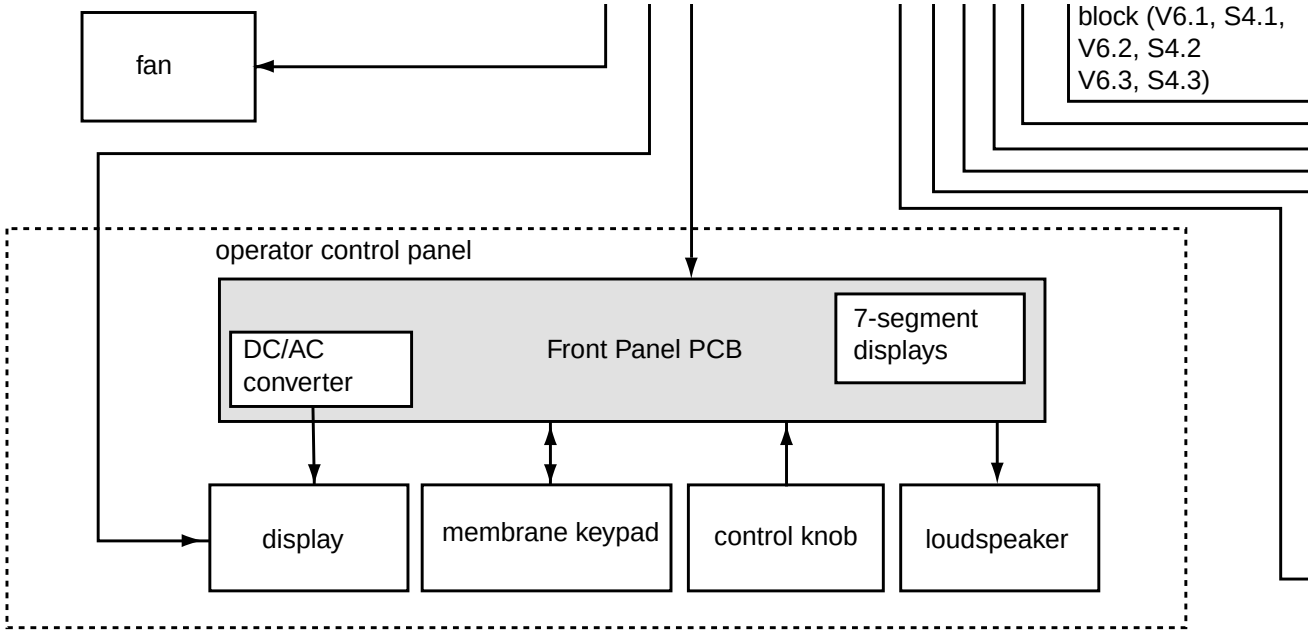

Fig.7: Operator control panel

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Front Panel PCB

The Front Panel PCB contains the 7-segment displays for the pre-set ventilation parameters, the drivers for the key LEDs, the drivers for interpretation of the keys and the shaft encoder, and the voltage generator for backlighting of the display. The voltage generation for the backlighting can be switched on and off from the Control PCB.

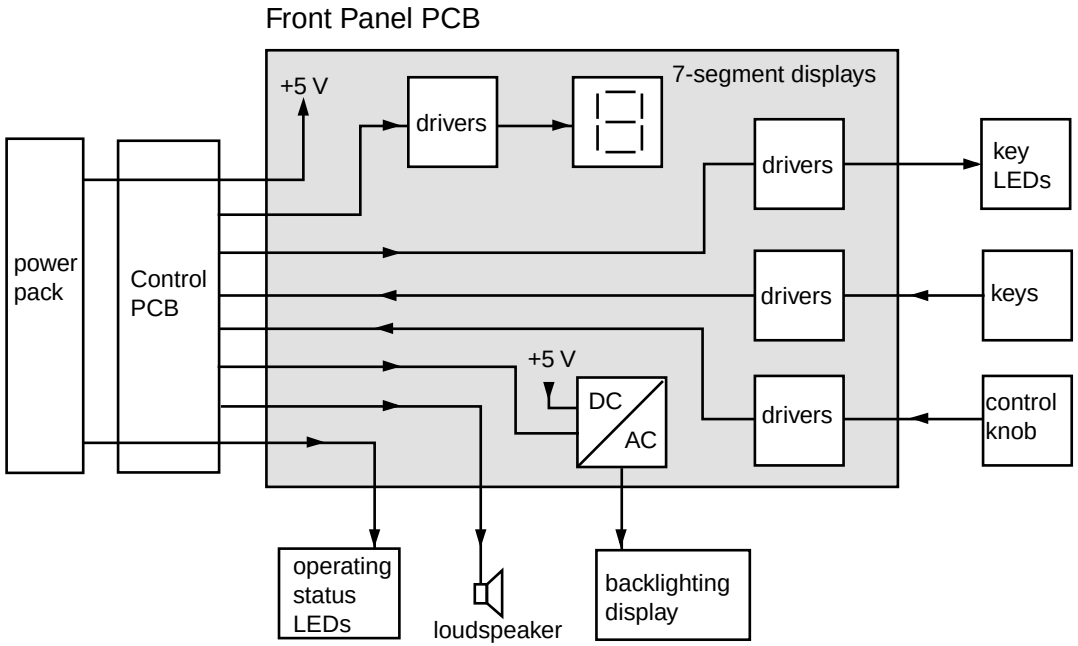

Fig.8: Block diagram of the Front Panel PCB

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Display

The display shows the patient parameters and the warning messages. The display is actuated by the Control PCB; the display backlighting is actuated by the Front Panel PCB. The display resolution is 240 x 128 pixels. The voltage supply is +5 V and —15 V.

Membrane keypad

The membrane keypad contains the keys, with associated LEDs, to operate Savina.

Control knob

The control knob is used to set and confirm changeable ventilation parameters. The control knob transmits square signals to the Front Panel PCB as it rotates, and the signals are then evaluated by the Control PCB. The voltage supply is +5 V.

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Pneumatic system

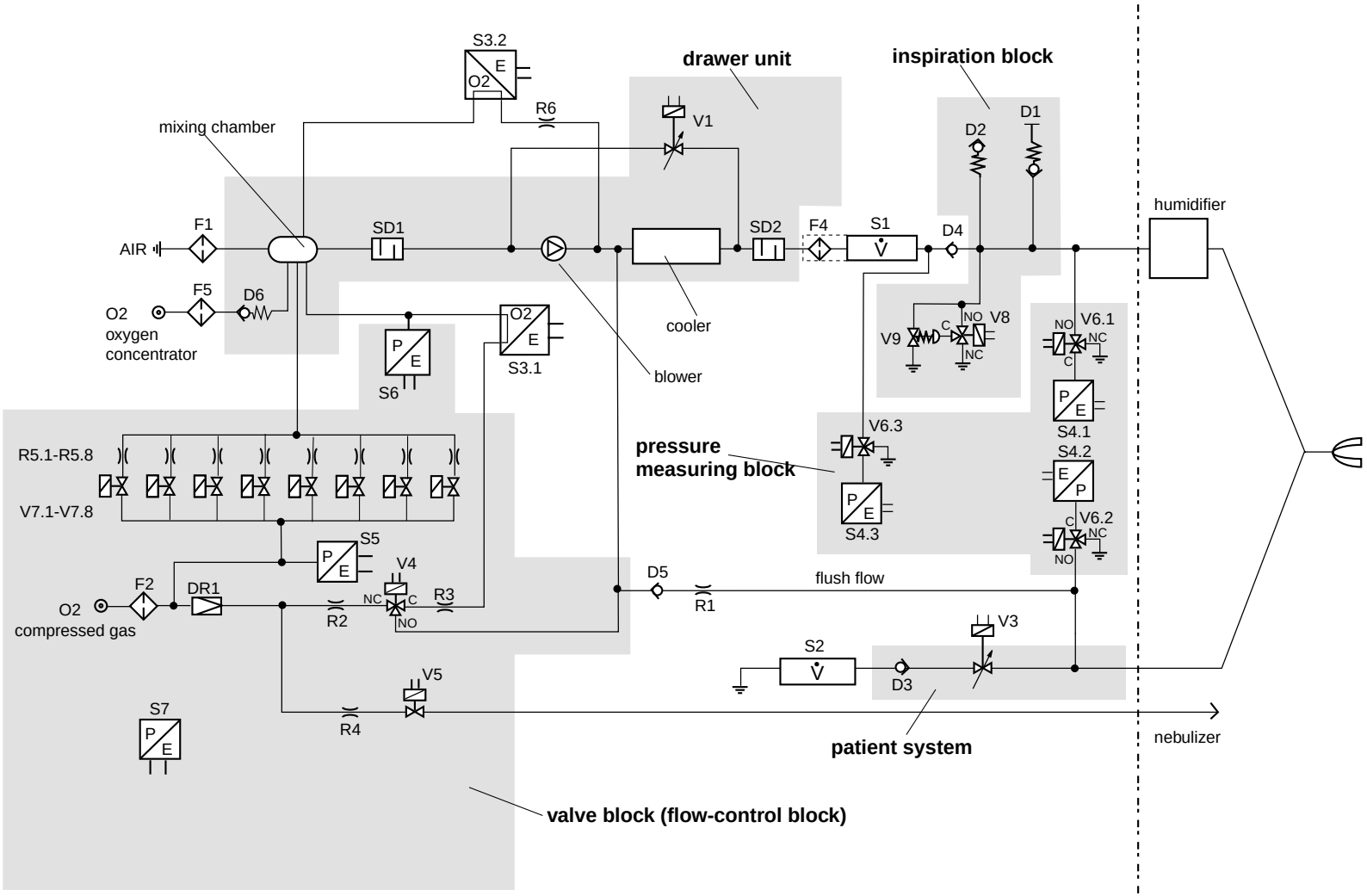

Fig.9: Pneumatic diagram

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Table 1: Key to Fig.9: Pneumatic diagram

Abbreviation	Designation
F1	Micro-filter (AIR).
F2	Filter (O_2).
F4	Filter for inspiratory flow sensor.
SD1	Suction sound muffler.
SD2	Muffler.
DR1	Oxygen pressure reducer.
Blower	Blower and motor.
Cooler	Cooler.
Injector	Injector.
V1	Bypass valve.
V3	Expiratory valve.
V4	Switching valve, oxygen compensation.
V5	Switching valve, nebulizer.
V6.1	Calibration valve, expiratory airway pressure sensor (located in inspiratory branch).
V6.2	Calibration valve, inspiratory airway pressure sensor (located in expiratory branch).

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Table 1: Key to Fig.9: Pneumatic diagram

Abbreviation	Designation
V6.3	Calibration valve, inspiratory airway pressure sensor (The airway pressure sensor regulates the blower. Only available in the first lot of units).
V7.1 -- V7.8	Oxygen flow-control valves.
V8	Electric emergency vent valve to operate the pneumatic emergency vent valve.
V9	Pneumatic emergency vent valve.
S1	Inspiratory flow sensor.
S2	Expiratory flow sensor.
S3.1	Oxygen sensor 1.
S3.2	Oxygen sensor 2.
S4.1	Expiratory airway pressure sensor (located in inspiratory branch).
S4.2	Inspiratory airway pressure sensor (located in expiratory branch).
S4.3	Inspiratory airway pressure sensor (The airway pressure sensor regulates the blower. Only available in the first lot of units).
S5	Oxygen supply pressure sensor.
S6	Pressure sensor (absolute pressure).
S7	Pressure sensor (absolute pressure).
D1	Safety valve (100 mbar to 120 mbar).

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Table 1: Key to Fig.9: Pneumatic diagram

Abbreviation	Designation
D2	Emergency air valve (–3 mbar to —6 mbar).
D3	Expiratory non-return valve.
D4	Inspiratory non-return valve.
D5	Non-return valve, flush flow.
D6	Non-return valve, oxygen port (1).
R1	Flush flow control valve (0.1 L/min at 30 mbar).
R2	O_2 calibration restrictor (0.1 L/min, integrated in valve block).
R3	Restrictor for O_2 measurement (0.2 L/min at 30 mbar, sensor 3.1).
R4	Restrictor for nebulizer (10 L/min, integrated in valve block).
R5.1 -- R5.8	Restrictors for oxygen flow control.
R6	Restrictor for O_2 measurement (0.2 L/min at 30 mbar, sensor 3.2).

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The pneumatic system comprises the following principal components (see also Fig.9: Pneumatic diagram):

– Drawer unit

– Valve block

– Inspiration block

– Pressure measuring unit

– Patient system

– Flow sensors

The following summary describes the functions of the various principal components rather than giving a detailed description of the components themselves.

Ventilation function

The blower draws ambient air through an ambient air filter F1 into a mixing chamber. The blower compresses the gas to a positive pressure of max. 140 mbar at a flow rate of up to 180 L/min. The blower is run at constant rotation speed - that is, the speed is not varied in the course of a breath. The inspiratory pressure is regulated by means of the bypass valve. The combination of the blower and the bypass valve function thus represents a pressure source.

On the inlet and outlet sides of the blower there are mufflers SD1 and SD2, which reduce the sound level of the blower.

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The bypass valve V1 is operated such that the desired respiratory pressure is applied to the blower outlet, and thus to the patient. In the inspiratory phase when a high flow rate is required by the patient, part or all of the gas flows from the blower outlet to the patient; the gas flow in the return line is reduced. In the expiratory phase the entirety of the blower gas flows via the return line.

A cooler reduces the respiratory gas temperature down to a permissible range. A fan blows cooling air onto the surface of the cooler to dissipate the heat from the cooler.

Expiration occurs via a directly operated valve V3.

The expiratory valve has two functions:

– Controls the PEEP during expiration

– Closes the breathing system during inspiration

O_2 mix

In order to be able to ventilate with an increased O_2 concentration, the unit must be supplied with 2.7 to 6.0 bar O_2. O_2 is filtered via the intake filter F2. With the aid of a digital valve block consisting of 8 digital solenoid valves, O_2 is supplied to a mixing chamber. The amount of supplied O_2 depends on the pre-set O_2 concentration and on the inspiratory flow rate measured by the flow sensor S1. The addition of O_2 is regulated in a closed loop. In the process, the inspiratory O_2 concentration is measured by the O_2 sensor S 3.1.

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Pneumatic safety devices

The independent pneumatic safety valve D1 ensures that the respiratory pressure can never rise above the legally prescribed limit of 120 mbar. In the event of inspiratory stenosis the pressure is limited by opening the expiratory valve. The mechanical negative-pressure valve D2 ensures (except in the case of inspiratory stenosis) that the patient can breathe spontaneously from the ambient air in case of a fault.

The emergency vent valve V9 relieves the pressure in the breathing system in a case of expiratory stenosis if the pressure cannot be relieved through the expiratory valve. The pilot valve V8 operates the emergency vent valve V9.

Nebulizer function

The drug nebulizer is operated with 100% O_2. The supply pressure regulator DR1 ensures, with widely varying supply pressure (2.7 to 6.0 bar), that the pneumatic drug nebulizer receives a constant supply pressure of 2.0 bar.

When the nebulizer function is active the solenoid valve V5 operates in an "inspiration" (open position) / "expiration" (closed position) cycle. When the nebulizer function is inactive valve V5 is permanently closed.

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O_2 calibration function

In normal operation of the unit the solenoid valve V4 is set to "measurement" - that is, the connection between the inspiration and the oxygen sensor is open. During O_2 sensor calibration it opens the way for the oxygen to the sensor. This layout permits online calibration of sensor S3.1 during ventilation. Sensor S3.2 must be calibrated manually (patient disconnected).

Sensors

The absolute pressure sensor S6 delivers the measured atmospheric pressure value required for O_2 measurement and for volume application. Absolute pressure sensor S7 monitors sensor S6. Sensor S3.1 delivers the signal for the displayed value FiO_2 and the signal for control of the inspiratory O_2 concentration. Sensor S3.2 monitors sensor S3.1.

The pressure sensor S4.1 measures the pressure in the inspiratory branch. The sensor signal, in conjunction with the expiratory pressure sensor S4.2, measures, controls and monitors the airway pressure. The airway pressure is measured on the basis of the measured value from the pressure sensor in the respective no-flow branch. Pressure sensor S4.3 continuously measures the airway pressure. The measured value is required to regulate the blower.

Solenoid valves V6.1, V6.2 and V6.3 calibrate the inspiratory pressure sensors and the expiratory pressure sensor. During calibration, the corresponding valve interrupts the connection to the ventilation circuit and switches the sensor to ambient pressure.

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Flow sensor S1 measures the inspiratory gas flow. Its measurement variable serves as the basis for calculation of the necessary oxygen flow and thus to operate the oxygen flow control valves V7.1 to V7.8, to control the mandatory breaths and to monitor the functions of the unit. The sensor includes a temperature measurement function to measure the inspiratory gas temperature.

Flow sensor S2 measures the flow via the expiratory valve to the outlet. The flow sensor used is the Spirolog sensor from the Evita series (temperature-compensated hot wire flowmeter with no detection of flow direction). The signal is used for patient monitoring (e.g. minute volume monitoring) among other applications.

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Conversion Instructions

List of Conversions

– Conversion kit software 1.12 Savina 84 14 660

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